# STUDY OF THE COELIAC TRUNK AND ITS BRANCHES IN 50 SPECIMENS

*Dissertation submitted in partial fulfillment of the requirement for the award of*

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# CERTIFICATE

This is to certify that the dissertation entitled **"STUDY OF THE COELIAC TRUNK AND ITS BRANCHES IN 50 SPECIMENS"** submitted by **Dr.D.Devi Jansirani,** postgraduate in Anatomy to the faculty of Anatomy, The Tamilnadu Dr. M.G.R Medical University, Chennai in partial fulfillment of the requirement for the award of M.S. Degree in Anatomy, is a bonafide work carried out by her under my direct supervision and guidance.

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# DECLARATION

I, **Dr.D.Devi Jansirani** solemnly declare that the dissertation entitled "**STUDY OF THE COELIAC TRUNK AND ITS BRANCHES IN 50 SPECIMENS"** has been prepared by me under the guidance and supervision of **Dr.V.Rajaram, D.L.O., M.S.**, Director & Professor I/C, Institute of Anatomy, Madurai Medical college, Madurai in partial fulfillment of the requirement for the award of **M.S. (Anatomy)** Degree Examination of **The Tamilnadu Dr. M.G.R Medical University, Chennai** to be held in March 2009. This work has not formed the basis for the award of any other degree to me from any other university.

Place: Madurai **DR.D.DEVI JANSIRANI**
Date:

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# *INTRODUCTION*

# INTRODUCTION

A good knowledge of arterial supply of the upper abdominal organ is very much essential for the surgeons, interventional radiologists and anatomists. During surgery, arterial variations cannot be ignored for the risk of ligating the wrong vessel or severing an essential artery resulting ischemia or bleeding.

Identification of replaced arteries is more important because that may be the only blood supply for that region, ligation of which may lead to fatal necrosis. Knowledge of accessory arteries is also a must to anticipate the presence of an additional artery during surgery.

The liver donor shortage and higher demand on liver transplantation lead to advanced liver surgical techniques for which the sound knowledge of arterial anatomy and its variation is very much mandatory.

Sometimes the aberrant hepatic artery for the left lobe of the liver takes origin from the left gastric artery. Lack of awareness of this vessel may lead to severing of the only blood supply of the left lobe and lead to ischemic necrosis.

Variations had been noticed in the origin of the left gastric artery from aorta instead of from coeliac trunk. This alerts the surgeons during the gastric surgeries.

The varied origin of common hepatic artery as a direct branch from aorta and the origin of superior mesenteric artery from coeliac trunk must be known by the gastroenterologists during the surgical procedures. The rare origin of middle colic artery from coeliac trunk must also be known by the surgeons because careless ligation of which may lead to the ischemic necrosis of the right two-third of the transverse colon.

The presence of aberrant right hepatic artery from superior mesenteric artery and its unusual course as running posterior to the head of the pancreas and posterior to the portal vein should be borne in mind during portocaval shunt surgeries and care should be taken not to interfere with the blood supply of the right lobe of the liver.

Knowledge of variation of vascular anatomy of liver and stomach and its relation to lymph nodes is required for gastroenterologists. Because lymphatic metastasis in carcinoma of stomach require dissection of nodes along these arteries, for which both normal and variational vascular anatomy is much essential.

A good knowledge of anatomy of splenic artery is very much essential during splenectomy, percutaneous interventional techniques such as partial splenic artery embolization, stent placement, etc.

Because of these surgical importance and the existence of wide variations in the arterial supply of supramesocolic organs and its need for surgeons, radiologists and anatomists, the study on coeliac trunk and its branches had been undertaken.

# *AIM OF THE STUDY*

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The present study of the coeliac trunk and its branches in 50 specimens had been focused on to study the branching pattern of the coeliac trunk, presence of supernumery branches from coeliac trunk and its branches, presence of any aberrant vessels and to compare the findings with the results of the previous studies.

# *REVIEW OF LITERATURE*

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**Haller (1756)** was the first to make an extensive work on coeliac trunk and its branches. He observed that the coeliac trunk divided into three branches the left gastric, the hepatic and the splenic artery and all these branches were found to take origin from a common point. Because of his work, such type of the coeliac trunk had long been known as the "Tripod of Haller". He reported that the coeliac trunk may be derived from the superior mesenteric artery. The coeliac trunk gave only the splenic and left gastric arteries, the hepatic from the superior mesenteric artery. The left gastric artery took origin from the splenic artery or directly from abdominal aorta.

**Eaton (1917)** classified the 206 coeliac trunks into 4 types. They were:

***Type I*** The left gastric artery and the splenic artery from a common trunk, the common hepatic artery arising from the aorta or from the superior mesenteric artery.

***Type II*** Tripod coeliac trunk with accessory hepatic arteries and a dorsal pancreatic artery.

***Type III*** Common trunk having the left gastric artery as its first branch showing accessory hepatic arteries and a pancreatic branch.

***Type IV*** The left gastric artery arise separately from aorta. The common hepatic artery and the splenic artery forming a common trunk with a pancreatic branch.

He observed Tripod of Haller in 15.5% of specimens. He found that all three major branches of coeliac trunk arose from aorta by a common stem in 86% as complete trunk, coeliac trunk from aorta, but incomplete (without any of the three branches) in 12.5%, coeliaco-mesenteric trunk in 1 % and absent coeliac trunk in 0.5%. He reported 11.2% of specimens had dorsal pancreatic artery from coeliac trunk.

**Lipshutz (1917)** dissected 83 cadavers and classified 4 types of coeliac trunk. They were:

***Type 1*** Common trunk for left gastric, splenic and hepatic arteries (75%)

***Type 2*** Common trunk for hepatic and splenic arteries. The left gastric artery from aorta as separate branch (15%)

***Type 3*** Common trunk for the hepatic and the left gastric arteries, splenic artery from aorta separately (6%).

***Type 4*** Common trunk for left gastric artery and splenic artery, common hepatic artery from aorta separately (4%).

He reported 75% of specimens had complete coeliac trunk and 25% had incomplete coeliac trunk. He found that the origin of accessory hepatic artery arises from the left gastric artery and from superior mesenteric artery in 19% of cases. He reported that in 3 cases cystic artery took origin directly from the superior mesenteric artery.

**Adachi (1928)** dissected 252 Japanese cadavers. He distinguished 6 types of coeliac trunk. They were:

***Type I*** The left gastric, the splenic and the hepatic artery from a common trunk (87.7%).

***Type II*** The left gastric artery from abdominal aorta. The hepatic artery and the splenic artery from a common trunk (6.3 %).

***Type III*** The left gastric as a direct branch of abdominal aorta. The hepatic, the splenic and the superior mesenteric artery from a common trunk (1.2%).

***Type IV*** The left gastric artery, the splenic artery, the hepatic artery and the superior mesenteric artery from a common trunk (2.4%).

***Type V*** The left gastric artery and the splenic artery from a common trunk. The hepatic and superior mesenteric artery arise from a common trunk (0.4 %).

***Type VI*** The left gastric artery and the splenic artery from a common trunk, the hepatic artery is missing. The liver is supplied by an aberrant right or left hepatic artery or both (2%).

He reported that the origin of accessory left hepatic artery from left gastric artery in 17.9% of cases, accessory right hepatic artery from the superior mesenteric artery in 10.3% cases, accessory right hepatic artery from coeliac trunk in 2% of cases. He described the middle hepatic artery arising from the right hepatic artery in 50% of cases, from left hepatic artery in 40% of cases and from proper hepatic artery in 10% of cases. He considered the artery as the specific artery for quadrate lobe.

**Pick and Anson (1940):** observed inferior phrenic artery taking origin from coeliac trunk in 47.8% out of 200 cadavers.

**Michels, Nicholas A (1955)** made an extensive study on the arterial supply of the supramesocolic organ. He dissected more than 500 cadavers. He statistically analyzed in 200 cadavers regarding the origin

and distribution of all the arteries in this region. Michels classified the coeliac trunk into 7 types. They were:

***Type I*** Hepatolienogastric trunk – the typical text book pattern of coeliac trunk dividing into the hepatic, the splenic and the left gastric arteries in 89% of cases. Tripod of Haller is seen in 20% of cases. In 5% of cases, dorsal pancreatic artery is seen as a branch of coeliac trunk.

***Type II*** Hepatolieneal trunk – coeliac trunk gives rise to hepatic and the splenic; the left gastric is displaced in 3.5% cases.

***Type III*** Hepatolienomesentric trunk – in 0.5% cases. Here the left gastric artery arise separately at the level of coeliac trunk directly from the aorta. The hepatic, the splenic and the superior mesenteric artery arise from a common trunk.

***Type IV*** Hepatogastric trunk – in 0.5% cases. The left gastric and the hepatic artery arise from a common trunk and the splenic artery arises from the superior mesenteric artery.

***Type V*** Lienogastric trunk – in 5.5% cases. The splenic and the left gastric artery arise from a common trunk and the hepatic artery is replaced from the abdominal aorta (2%) and from the superior mesenteric artery (2.5%).

***Type VI*** Coeliaco-mesenteric trunk (0.4%). The four arteries hepatic, splenic, left gastric and the superior mesenteric artery arise from abdominal aorta by a common trunk.

***Type VII*** Coeliaco-colic Trunk (2 cases).In this type the middle colic (1 case) or the left colic artery (1 case) took origin from the coeliac trunk instead of from the superior mesenteric and inferior mesentric arteries.

In the textbook of Anatomy for Surgeons by **Henry Hollinshead (1961)**, it was stated that the coeliac trunk is a large, short trunk of 1-3 cm long, which typically arises from the aorta just as this vessel enters the abdomen.

**Dr. Kalavathy (1980**) reported that the coeliac trunk gave origin to dorsal pancreatic artery in 10% out of 75 specimens.

**Vandamme JP Bonte J (1985**) observed that the coeliac trunk bifurcated into the splenic and hepatic artery, and the left gastric artery seemed to have a variable origin between the aorta and coeliac trunk. The direction of the coeliac trunk was influenced by the topography of the pancreatic neck and by the origin of the hepatic artery. If the coeliac trunk is not the origin of hepatic artery, it is not directed to the right, but to the left. It is the hepatic artery that pulls the coeliac trunk to the right.

**Shoumura S *et al* (1991)** studied the mode of branching of the coeliac trunk in 184 Japanese cadavers. The findings were as follows; 166 of the 184 cases belonged to Type I of Adachi's classification of variation in the arrangement of the branches of the coeliac trunk, 7 cases belonged to Type II, 2 cases belonged to Type III, 1 case belonged to Type IV, 3 cases belonged to Type V and 2 cases belonged to Type VI of which 1 case had a gastrolienal trunk and an accessory right hepatic artery arising from the superior mesenteric artery. The other one had a gastrolienal trunk and an accessory right hepatic artery arising from the gastrolienal trunk. Of the 184 cases, three could not be classified according to Adachi. 2 cases had a gastrolienal trunk and the hepatic artery arising from the abdominal aorta. 1 case had a lienomesenteric trunk and a gastrohepatic trunk.

**Yamaki K *et al* (1995**) reported a rare case of absence of coeliac trunk. In this case, the left gastric, the splenic and the common hepatic arteries arose independently in that order from the abdominal aorta and also the left aberrant hepatic artery from the left gastric artery.

**Higashi N *et al* (1995)** described that all the three branches of coeliac trunk arose directly from the abdominal aorta.

**Başar R *et al* (1995)** encountered a unique case of “agenesis of the coeliac trunk” in a 42-year-old Turkish male. There was instead an

artery which arose from the aorta and supplied blood to the territory of both the coeliac and superior mesenteric arteries by giving rise to the splenic, the jejunal, the ileal, the pancreaticoduodenal, the proper hepatic and the left gastric arteries.

**Cavdar S *et al* (1997)** observed a rare variation of coeliacomesenteric trunk during the dissection of a 54-year-old male cadaver. The rare occurrence of this variation is stated to be 1% to 2.7%

**Cavdar S *et al* (1998)** described a case in which the left inferior phrenic artery and left gastric artery arose from the long coeliac trunk (4.3 cm.) via a common trunk.

**Murakami T *et al* (1998)** observed an anomaly of absent coeliac trunk in the postmortem of a Japanese adult male in which the left gastric, common hepatic, splenic arteries arose independently from the abdominal aorta.

**Piao Dx *et al* (1998)** dissected 68 Japanese cadavers and stated that inferior phrenic arteries arise from the coeliac trunk in 28.2% cases and from the left gastric artery in 2.9% cases.

**Hiarari Y Yamaki K *et al* (2000)** reported a case in which the usual trunk was not identified and the hepatolienomesentric and the gastrophrenic trunks were independently arising from the abdominal

aorta. In addition the common hepatic artery divided into the left hepatic, right hepatic and gastro duodenal arteries simultaneously.

**Witte B *et al* (2001)** observed during dissection of an 89-year-old female cadaver, in which the coeliac trunk gave off four arteries: the hepatic, splenic, left gastric arteries and an additional dorsal pancreatic artery.

**Kahraman G *et al* (2001)** reported a hepatomesenteric trunk, formed by the common hepatic and superior mesenteric arteries in a 50-year-old male cadaver. The left gastric and splenic arteries arose as a common trunk, the gastrosplenic trunk, from the abdominal aorta.

**Bordei P *et al* (2002)** dissected in 60 human fetus and found different patterns of coeliac trunk to be gastro-hepatic trunk, with the splenic artery directly from the aorta or from the hepatic artery; gastrosplenic trunk, with the hepatic artery originating from the aorta; hepato-splenic trunk, with origin of the left gastric artery either directly from the aorta or from the hepatic artery. Rare variations: coeliacomesenteric trunk; two arterial trunks, hepato-splenic and hepato-gastric; separate aortic origin for all three "classic" branches of the coeliac trunk; two hepatic arteries, one from the coeliac trunk and the other from the aorta or superior mesenteric artery.

**Nakamura Y *et al* (2003)** presented three cases of the gastrosplenic and the hepatomesenteric trunks in Japanese cadavers. Especially, in Case 1, the left inferior phrenic artery arose from the gastrosplenic trunk and the left hepatic artery arose from the left gastric artery. In Cases 2 and 3, the common hepatic artery penetrated the pancreatic parenchyma before reaching liver. In Case 3, the right hepatic artery arose from the hepatomesenteric trunk.

**Saeed M *et al* (2003)** reported the coexistence of multiple anomalies: a short lienogastric trunk; a common hepatic artery arising directly from the abdominal aorta; a common inferior phrenic trunk arising from the coeliac trunk.

In the textbook of **Gray's Anatomy, The Anatomical basis of clinical practice (2005)**, it is stated that the coeliac trunk is the first anterior branch of aorta. It is 1.5 to 2 cm long. It divides into left gastric, common hepatic and splenic arteries.

**Demirtas K *et al* (2005)** found the coeliac trunk to emerge from the abdominal aorta as 2 roots named hepatogastric trunk and hepatosplenic trunk. The hepatogastric trunk arises from the anterior surface of the abdominal aorta and divides into an aberrant branch to the right lobe of the liver, a branch to the right hemi-diaphragm, the left hepatic and the left gastric arteries. The hepatosplenic trunk, which arises 1.5 cm below

the hepatogastric trunk, gave off the common hepatic and splenic arteries.

**Çiçekcibaşi AE *et al* (2005)** observed a rare variation, a coeliacomesenteric trunk. This trunk gave rise to the left gastric, the common hepatic, the splenic, the left gastroepiploic, the right and left inferior phrenic arteries.

**Peschaud F *et al* (2006)** found a variation of absent coeliac trunk. The left gastric artery and the splenic artery arose directly from the aorta, without coeliac trunk separation. The common hepatic artery was unusual in that it formed the first branch of the superior mesenteric artery, and passed in front of the portal vein to reach the hilum of the liver, where it divided into a right and a left branch.

**Karakose M *et al* (2006)** encountered the coeliac trunk divided into the left gastric, hepatic, splenic, and dorsal pancreatic arteries during a routine upper abdomen dissection of a 62-year-old male cadaver.

**Ucerler H *et al* (2006)** observed that the branches of the coeliac trunk were arising from two different trunks as the upper and below ones. The trunk at the upper was gastrophrenic trunk and the trunk at the below was hepatosplenic trunk.

**Yi SQ *et al* (2007)** reported a rare variation, a common coeliacomesenteric trunk. The trunk gave rise to left gastric, common hepatic, splenic and superior mesenteric arteries.

**Review of Literature for Hepatic Artery**

**Rossi and Cova (1904)** dissected about 102 bodies and they had observed that the hepatic artery as a direct branch from the abdominal aorta in 4 cases.

**Pedro Belour (1915)** found that the aberrant right hepatic artery from superior mesenteric artery or from the coeliac trunk passed behind the portal vein after its origin.

**E.R. Flint (1922-23)** dissected 200 cases and found that the right hepatic artery taking origin form coeliac trunk in 158 cases and from the superior mesenteric artery in 42 cases. In 7 cases, there are two right hepatic arteries one from the coeliac trunk and other from the superior mesenteric artery. He also stated that the cystic artery arose from the right hepatic artery in 196 cases, from the left hepatic artery in 3 cases and from gastroduodenal artery in 1 case.

**Thompson (1933)** made observations on 50 cadavers and found that aberrant hepatic arteries in 28% of cases.

**Reginald H Jackson (1940)** stated that in 20% of cases the blood supply of right lobe of liver comes from the superior mesenteric artery.

**John M Pierson (1943)** described that an anomalous right hepatic artery arising from the superior mesenteric artery in 10% cases; Out of 10%, 8% is replaced right hepatic artery and 2% is accessory right hepatic artery. All these arteries passed dorsal to the head of the pancreas.

**Daseler *et al* (1947)** made an extensive study of hepatic artery and its branches in 500 cadavers and reported that the origin of common hepatic artery from the coeliac trunk in 83.2% cases, from superior mesenteric artery in 4.4% cases, from abdominal aorta in 0.2% case and absent in 1.4% cases. They found that the right hepatic artery arising normally from the proper hepatic artery in 83.2% cases, as replaced right hepatic artery of superior mesenteric artery origin in 11.2% cases, from the replaced common hepatic of superior mesenteric artery in 4.4% cases, as a direct branch of coeliac trunk in 0.8% cases, from the replaced common hepatic of aortic origin in 0.2 % cases, as a direct branch of abdominal aorta in 0.2% cases. They found the presence of accessory right hepatic artery in 7.2% cases of which 3% cases arise from the superior mesenteric artery, as a branch of left hepatic in 2.6 %

cases, as a branch of gastroduodenal artery in 1% cases, from coeliac trunk in 0.4% cases and from abdominal aorta in 0.2% cases. Regarding the left hepatic artery, they found its origin from proper hepatic artery in 87% cases, replaced left hepatic artery in 18% cases and accessory left hepatic artery in 35% cases. They also found the origin of right gastric artery from proper hepatic artery in 50% cases, from left hepatic artery in 32.4% cases, from right hepatic artery in 4% cases, from gastroduodenal artery in 13.2% cases and as a direct branch of coeliac trunk in 0.4% cases.

**Dorvan A Moosman *et al* (1951)** dissected 250 cadavers and found that normal right hepatic artery from coeliac axis in 85.6% cases (214 cases) and aberrant right hepatic arteries in 18.4% cases (46 cases). Out of these 46 cases, 36 were replaced right hepatic artery and 10 were accessory right hepatic artery. It was stated that cystic artery taking origin from right hepatic artery in 86% cases, from replaced right hepatic artery in 10% and origin from other sources 4%.

**Edward V Johnson *et al* (1952)** dissected 35 specimens and concluded as follows: coeliacal common hepatic artery present in all cases of which in 91.4% (32 specimens) is complete giving both right and left hepatic artery. But in 2 specimens, it continued only as left hepatic artery and in 1 specimen it continued as the middle hepatic artery alone.

Gastroduodenal artery arise form the hepatic artery in all specimens studied. Right hepatic artery took origin from the proper hepatic artery in 32 specimens, as replaced right hepatic artery from superior mesenteric artery in 3 specimens (8.6%) and as accessory right hepatic artery in 4 specimens (11.4%). Left hepatic artery took origin as a branch of proper hepatic artery in 32 specimens. Right gastric artery out of 31 specimens recorded, it took origin from proper hepatic artery in 18 specimens, from left hepatic artery in 11 specimens, and from gastroduodenal artery in one specimen. In 7 specimens, aberrant right hepatic artery of superior mesenteric artery origin coursed posterior to portal vein.

**Michels (1955)** made a detailed study on the hepatic artery and its branches. He classified the hepatic artery into 10 types. They were:

***Type-I*** The right, left and middle hepatic arteies-55%

***Type-II*** The right and the middle hepatic artery; Left hepatic artery replaced form the left gastric artery -10%

***Type-III*** The left and middle hepatic artery; Right hepatic artery replaced from the superior mesenteric artery-11%.

***Type-IV*** Only middle hepatic artery; the right hepatic artery and left hepatic artery replaced form the left gastric artery - 1%.

***Type V*** The right, middle and the left hepatic artery. An accessory left hepatic artery from left gastric artery - 8%

***Type VI*** The right, middle and the left hepatic artery. An accessory right hepatic artery form superior mesenteric artery - 7%.

***Type VII*** The right, middle and the left hepatic arteries. An accessory left hepatic artery from left gastric artery and an accessory right hepatic artery form superior mesenteric artery - 1%.

***Type VIII*** Combination pattern of the replaced right hepatic artery and an accessory left hepatic artery (or) an accessory right hepatic artery and replaced left hepatic artery - 2%.

***Type IX*** Classical coeliacal hepatic artery was absent. The common hepatic artery form superior mesenteric artery - 4.5%

***Type X*** The coeliacal hepatic artery is absent. The entire hepatic artery is derived from the left gastric artery - 0.5%.

Michels stated that aberrant right hepatic arteries of superior mesenteric artery origin proceeded posterior to the portal vein. He reported about the origin of right gastric artery from proper hepatic artery in 40%, from left hepatic artery in 41%, from right hepatic artery in 5.5% and from gastroduodenal artery in 8% of specimens. He found that middle hepatic artery took origin from right hepatic artery in 45%, from left hepatic artery in 45% and from other sources like proper

hepatic artery in 10% of specimens. He observed the origin of cystic artery from right hepatic artery in 78%, from replaced right hepatic artery in 17%, from other sources in 5% of specimens .

**Frederic *et al* (1980)** analyzed the embryology of coeliac and superior mesenteric arteries. He stated that abnormal persistence or retrogression of primitive arterial segments account for the vascular anomalies. He discussed about the anomalous right hepatic artery of superior mesenteric origin in 18 to 20% of population and their importance in portocaval shunt surgery.

**Eckmann I Krahn (1984)** reported the origin of the right gastric artery from proper hepatic artery in 53% cases, from left hepatic artery in 15% cases, from the level of bifurcation of the proper hepatic artery in 20% cases, from gastroduodenal artery in 8% cases and from common hepatic artery in 4% cases.

**Margaret M Kemeny *et al* (1986)** investigated hepatic artery in 100 patients by arteriography and found that normal hepatic artery in 50% cases, replaced right hepatic artery in 20% cases, replaced left hepatic artery in 4% cases, right and left hepatic artery is separately from coeliac trunk in 1% cases, trifurcation of the common hepatic artery into gastroduodenal, right and left hepatic artery in 9% cases.

**Rang G.H. Stedelor WF (1987)** studied in 120 patients by angiography and found that normal hepatic artery in 66% cases, aberrant right hepatic artery of superior mesenteric artery in 16% cases, aberrant left hepatic artery from left gastric artery by 11% cases.

**Jonathan *et al* (1994)** studied the anatomical variations of the hepatic arteries in the 1000 donor livers for transplantation and classified the variations into 5 types.

***Type I*** Common hepatic artery from coeliac trunk and gave gastroduodenal artery and proper hepatic arteries; proper hepatic artery divided into right and left hepatic arteries - 75% cases.

***Type II*** A replaced or accessory left hepatic from left gastric artery - 9.7% cases.

***Type III*** A replaced or accessory right hepatic artery from superior mesenteric artery - 10.6% cases.

***Type IV*** The right hepatic artery from superior mesenteric artery and the left hepatic artery from left gastric artery - 4.5% cases.

***Type V*** The entire common hepatic artery as a direct branch of aorta - 0.2% cases.

**Hiatt JR *et al* (1994)** studied the anatomic variations in the hepatic arteries 1000 donor livers and observed that:

***Type 1*** (n = 757) Normal anatomy, with the common hepatic artery arising from the coeliac axis to form the gastroduodenal and proper hepatic arteries and the proper hepatic dividing distally into right and left branches.

***Type 2*** (n = 97), with a replaced or accessory left hepatic artery arising from the left gastric artery.

***Type 3*** (n = 106), with a replaced or accessory right hepatic artery originating from the superior mesenteric artery.

***Type 4*** (n = 23), with both right and left hepatic arteries arising from the superior mesenteric and left gastric arteries, respectively.

***Type 5*** (n = 15), with the entire common hepatic artery arising as a branch of the superior mesenteric artery.

***Type 6*** (n = 2), with the common hepatic artery originating directly from the aorta.

**Nakayasu *et al* (2000)** by biphasic helical CT reviewed in 166 patients and found the presence of aberrant right hepatic artery in 15% of which

replaced right hepatic artery from superior mesenteric artery in 10.2% and from other sources in 4.8%.

**Futura Ali *et al* (2001)** investigated in 110 post mortem cadaver specimens in detail and found that right hepatic artery taking origin from proper hepatic artery in 66.3% specimens, common hepatic artery in 18.2% specimens, superior mesenteric artery in 8.2% specimens, coeliac trunk in 7.3% specimens. Accessory right hepatic artery taking origin from superior mesenteric artery in 7% specimens, gastroduodenal artery in 2% specimens, left hepatic artery in 1% specimen. Left hepatic artery taking origin from proper hepatic artery in 71.8% specimens, common hepatic artery in 16.4% specimens, coeliac trunk in 10.9% specimens, splenic artery in 0.9% specimen.

**Bertevello PL *et al* (2002)** disseceted in 60 cadavers and found that the right hepatic artery araised from coeliac trunk in 44 (73.3%) cases, and in 15 cases (25%) from superior mesenteric artery; it was accessory in 11 (18.3%) cases. The accessory left hepatic artery of left gastric artery in 2 (3.3%) cases. Hepatic artery trifurcation was found in 9 (15%) cases.

**Arjhansiri K *et al* (2006)** evaluated hepatic artery variations in 200 patients by angiography and found that normal pattern in textbook descriptions 80.5%, a replaced or accessory right hepatic artery

originating from the superior mesenteric artery in 11.5% cases and a replaced or accessory left hepatic artery originating from the left gastric artery in 5.5%. In 0.5% of the cases, there was a combination of variations of both right and left hepatic arteries. Variants of the common hepatic artery arising from the superior mesenteric artery were found in 0.5%.

**Review of Literature for Splenic Artery**

**Arantius (1571)** was the first to describe the tortuosity of the splenic artery.

**Franz (1896)** in his short series of 28 cases found that the splenic artery running along the upper border of the pancreas in 12 cases, behind it in 10 cases, somewhat above it in 4 cases and front of it in 2 cases.

**Michels (1942)** found the varying length of the splenic artery from 8 to 32 cm. Among 100 specimens, he found the origin of splenic artery from aorta in one specimen. He also reported an accessory splenic artery which was actually a superior polar artery running parallel to the splenic artery. He observed the presence of superior polar artery in 65% and inferior polar artery in 82% of specimens.

**Katritsis E *et al* (1982**) reported that the superior polar artery in 60.0% and inferior polar artery in 80.0% of specimens are given from the splenic trunk.

**Trubel W *et al* (1988)** studied the splenic arteries of 126 cadavers and found a cranio-sinistrally directed branch from splenic artery in 76.2%. It appeared as a posterior gastric artery (only stomach supply) in 27.7% and as a superior polar artery (only splenic supply) in 3.27%. In the most cases an intermediate type called as "gastrosplenic artery" having a posterior gastric and a superior polar branch simultaneously was detected. Such a "gastrosplenic artery" leaves the main trunk of the splenic artery in its middle segment.

**Sylvester PA *et al* (1995)** studied 29 cadaveric specimens and 44 coeliac angiograms. The straight distance from the origin of the splenic artery, from the coeliac trunk, to the point of commencement of the hilar branches was measured, as was the total length of the artery between these two points. The ratio of these two measurements is called the "index of tortuosity."

**Liu DL *et al* (1996)** observed 850 spleen specimens and found the existence of the superior and inferior polar arteries and of the coexistence of both polar arteries were 31.3%, 38.8%, and 13.3% respectively.

**Seok Kil Zeon *et al* (1998)** studied the angiographic branching pattern of splenic artery in 43 splenic arteriograms and 7 coeliac arteriograms

and found 76% of cases had superior polar artery and 24% had inferior polar artery.

**Jauregui E (1999)** found that the splenic artery originates, in all cases, from the coeliac trunk, and this artery is the most important with an average length of 10.6 centimeters.

The branches are noted to be superior polar artery appearing in 53% of the cases, inferior polar artery appearing in a 33%.

**Daisy Sahni A.*et al* (2003)** found that the posterior gastric artery arose from about the middle of the splenic artery.

**Pandey SK *et al* (2004)** studied the splenic artery in 320 cadavers. They found the origin of splenic artery from coeliac trunk (90.6%), aorta (8.1%) & other sites (1.3%). suprapancreatic course of the artery was commonly observed (74.1%) followed by enteropancreatic (18.5%), intrapancreatic (4.6%), and retropancreatic (2.8%) courses.

**Review of Literature for Left Gastric Artery**

**Eaton (1917)** in his study of vasculature of the stomach, found the origin of left gastric artery from aorta in 4.5% of specimens.

**Lipshutz (1917)** in his study of 83 cases, found the origin of left gastric artery from aorta in 1.5%. He reported that the left gastric artery divided into two branches anterior and posterior to both surfaces of stomach.

**Reeves (1920)** described the left gastric artery as commonly dividing, into an anterior and posterior branch to supply the stomach.

**Michels (1952)** in his study found that the incidence of the origin of left gastric artery from aorta was 2.5%.

**Naidich JB *et al* (1978)** studied 500 angiograms and reported that in 13 of 500 cases, the left gastric artery arose anomalously most often as a direct branch of the aorta; in 14 of 500 cases, the left gastric artery primarily supplied the liver with only minor contributions to the stomach. An aberrant origin of the left gastric artery necessarily influences the angiographic diagnosis and therapy of gastrointestinal hemorrhage.

**Rao AK *et al* (1978)** reported the origin of the left gastric artery from the aorta in the arteriographic evaluation in two cases.

**Sawai K *et al* (1984)** studied the coeliac angiography in 296 gastric cancer patients and found that left gastric artery emerged from the coeliac trunk in 94.9%, splenic artery in 2.7%, abdominal aorta in 2.1%, and common hepatic artery in 0.3%. The accessory hepatic arteries emerged from left gastric artery in 17.9% of the cases.

**Yildirim M *et al* (1998)** found during the dissection of a 48 year old male cadaver, the left gastric artery was observed directly originating

from the abdominal aorta. The rare occurrence of this variation is stated to be 0.5% -1.5%.

**Ray CE Jr *et al* (1998)** reported 2 cases, in which the left gastric artery had replaced origin from superior mesenteric artery.

# *MATERIAL AND METHODS*

# MATERIAL AND METHODS

The study was conducted in the Institute of Anatomy, Madurai Medical College, Madurai- 625020.

**Sample Study:**

The study was done in 50 human cadaveric specimens. Of the 50 specimens, 22 were done in the dissection hall cadavers, 28 were collected from the post mortem among the Indian population irrespective of age and sex (Fig.1). Apart from these 50 specimens, a radiological study had been done in one patient. The radiological study was not included among the 50 specimens.

**Collection of Specimens:**

Post mortem specimens were collected from the Institute of Forensic Medicine, Madurai Medical College, Madurai.-20. By an I-shaped incision extending from the suprasternal notch to pubic symphysis, anterior chest wall was opened. The heart and lungs were removed from the thorax. The thoracic aorta, thoracic part of inferior

vena cava and oesophagus were tied, cut and removed proximally. Distally the abdominal aorta and inferior vena cava were tied and cut below the level of origin of the renal arteries and removed along with abdominal diaphragm, liver, spleen, stomach and pancreas in toto. The specimens were washed in the running water. 300 – 400 ml of 10%

**Fig 1. The postmortem specimens of the present study.**

formalin was injected through one cut end of the abdominal aorta using a 20 ml syringe and then the specimens were completely immersed in the buckets containing 10% formalin solution and were preserved for 10 days.

**Materials Used:**

- Stainless steel student's scalpel.
- Stainless steel forceps- toothed and non- toothed.
- Stainless steel long and short straight scissors.
- Knife and bone cutter.
- Black cream sheet, Rubber sheet, Graduated scale, HB pencil, 0.4mm thread and Cotton.
- Gloves and Apron
- Covered container for preserving specimens in formalin.
- 10% formalin.
- 20 ml syringe.

- Sodium diatriazoate contrast medium.

## METHOD OF STUDY

### 1. Gross Dissection:

***a) In dissection hall specimens:***

Manual dissection was done in 22 dissection hall cadavers. According to the textbook of Cunningham's manual of Practical Anatomy, abdominal cavity was opened by cutting and reflecting the muscles of anterior abdominal wall. The liver was pulled superiorly and its inferior margin was tilted anteriorly to expose the lesser omentum. The anterior layer of lesser omentum was removed close to the lesser curvature of the stomach and the left gastric artery was traced along its gastric and oesophageal branches. The right gastric artery was traced to the proper hepatic artery. The branches of proper hepatic artery were traced. The gastroepiploic arterial arcade in the greater omentum was identified and dissected. The anterior layer of the greater omentum was cut 2.3 cm inferior to the arteries and the omental bursa was opened.

The stomach, right gastric and gastro-epiploic vessels were cut immediately to the left of the pylorus and turned to the left. The coeliac trunk was identified. The dense autonomic plexus around the trunk and its branches were removed and the branching pattern had been noticed. The splenic artery was traced along the superior border of pancreas and its branches were noticed. All the findings were recorded.

***b) In postmortem specimens:***

Manual dissection was done in the 28 post mortem specimens regarding the origin of the coeliac trunk and its branches. The arteries supplying the liver, stomach, pancreas and the spleen were dissected according to the above said procedure and the findings were recorded.

***2. Radiological Study:***

This study was done in one patient. It was not included in the present study. These images had been taken with the help of MDCT (multi-detector computerized tomography) with the administration of contrast medium.

About 40 ml of sodium diatriazoate contrast medium at the concentration of 76% w/v was injected using power injector at the rate of 3 to 10 ml/sec and CT helical images were taken simultaneously. The raw digital data obtained was subjected to reconstruction process using filtered back projection method and 3D imaging was obtained by surface

rendering and volume rendering principle. This type of imaging provide better view of overlapping vessels.

The important structures that had been encountered in this current study are:

1. ***Coeliac Trunk:***
    - Pattern of the trunk
    - Presence of Tripod of Haller
    - Length
    - Supernumery branches like Inferior phrenic artery, Dorsal pancreatic artery, etc.
2. ***Branches of the Coeliac Trunk:***

***a) Hepatic artery:***

- Origin of the hepatic artery
- Terminal branches of the hepatic artery viz. right hepatic artery and left hepatic artery.
- Aberrant branches - both accessory and replaced arteries.
- Other branches of hepatic artery like gastroduodenal artery, right gastric artery and cystic artery.

***b) Splenic artery***

- Origin

- Length
- Tortousity index
- Branches

***c) Left gastric artery:***

- Origin
- Supernumery branches.

# OBSERVATIONS

By manual dissection of the coeliac trunk and its branches in 50 human specimens, the following observations were made.

## COELIAC TRUNK

### 1. Origin:

In all the 50 specimens, coeliac trunk took origin from the ventral surface of the abdominal aorta just below the crura of the diaphragm.

### 2. Direction of Inclination:

In 49 specimens, coeliac trunk most inclined towards the right side and passed forwards and downwards. In 1 specimen, coeliac trunk inclined more towards left side. It was Lienogastric trunk with replaced common hepatic artery from aorta. This inclination to the left side was due to the absence of the pull exerted by coeliacal hepatic artery.

### 3. Pattern of Coeliac Trunk:

The various pattern of coeliac trunk observed in the current study were: (Table 1), (Chart 1)

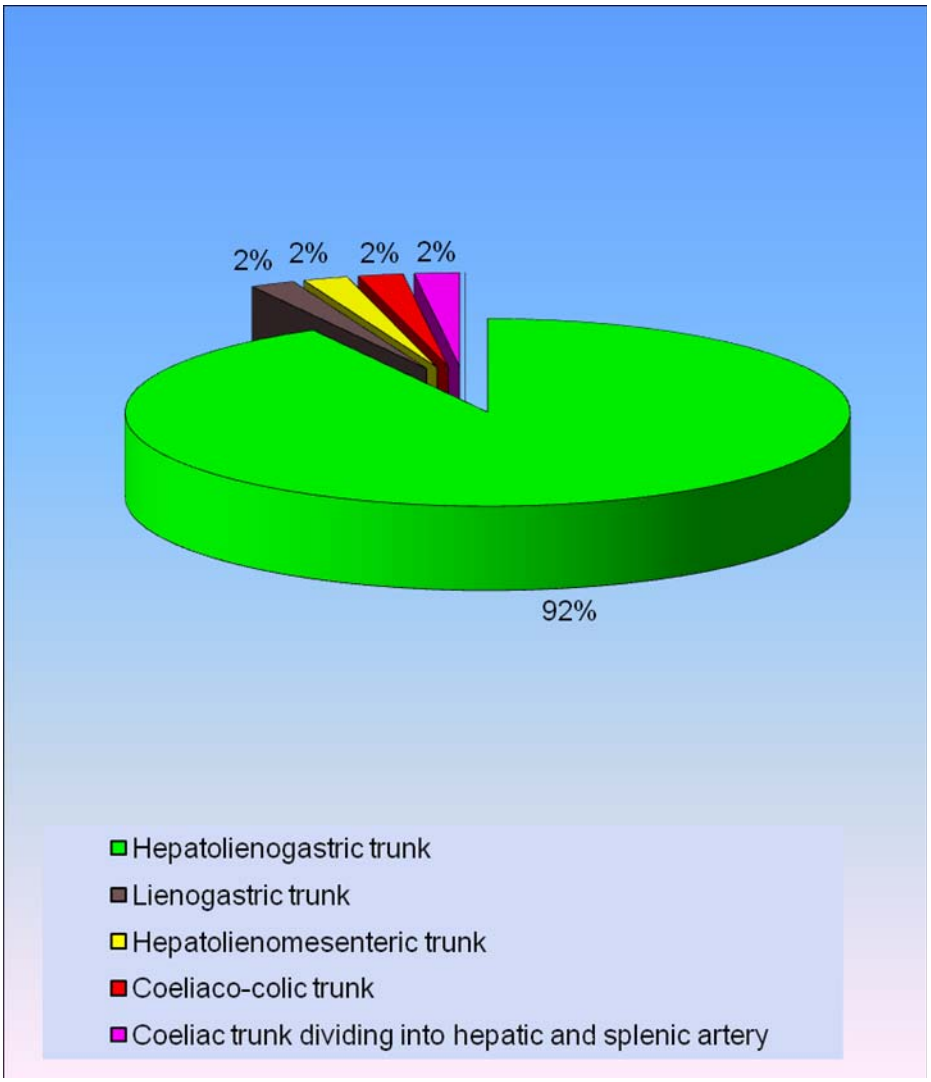
***(a) Hepatolienogastric trunk***:

In 46 specimens, the coeliac trunk divided into common hepatic, left gastric and splenic arteries as classical text book pattern (Fig.2).

**Table -1**
**Various Pattern of Coeliac Trunk**

| Sl. No | Pattern | No. of Specimens | Percentage |
|---|---|---|---|
| 1. | Hepatolienogastric trunk | 46 | 92% |
| 2. | Lienogastric trunk | 1 | 2% |
| 3. | Hepatolienomesenteric trunk | 1 | 2% |
| 4. | Coeliaco-colic trunk | 1 | 2% |
| 5. | Coeliac trunk dividing into hepatic and splenic artery | 1 | 2% |

**Chart - 1**
**Various Pattern of Coeliac Trunk**



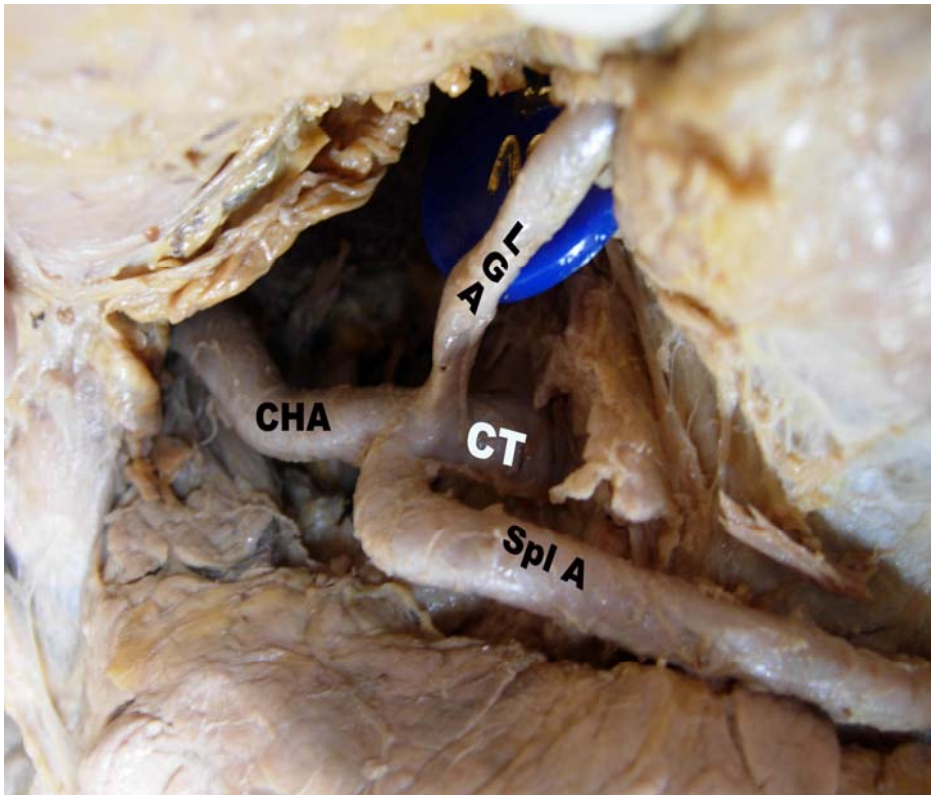



**Fig. 2. Hepatolienogastric trunk – normal pattern**

***(b) Lienogastric trunk:***

In one specimen, the coeliac trunk branched to the left gastric and splenic artery with left inferior phrenic artery as a supernumery branch. The common hepatic artery arose from the aorta a little below the origin of lienogastric trunk (Fig.3a). The aorta was opened and two separate ostia for the origin of coeliac trunk above and the common hepatic artery below were visualized (Fig. 3b).

***(c) Hepatolienomesenteric trunk:***

In one specimen, the common hepatic artery, splenic artery and superior mesenteric artery arose together as hepatolienomesenteric trunk with dorsal pancreatic artery as a supernumery branch from it. The left gastric artery had replaced origin directly from the aorta, a little above the origin of hepatolienomesenteric trunk and it gave both inferior phrenic arteries leading to the formation of the gastrophrenic trunk (Fig.4).

***(d) Coeliaco-colic trunk:***

In one specimen, it was noted that the coeliac trunk apart from dividing into common hepatic, left gastric and splenic arteries, it also gave origin to middle colic artery. The middle colic artery descended

down in the transverse mesocolon and supplied the right two-third of the transverse colon by its vasa recta (Fig.5).

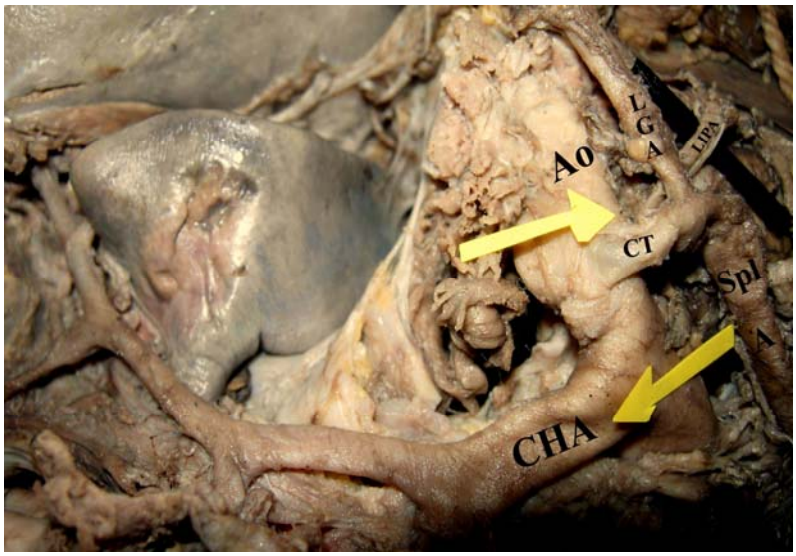



**Fig.3(a). Lienogastric trunk. Left inferior phrenic artery from coeliac trunk.**

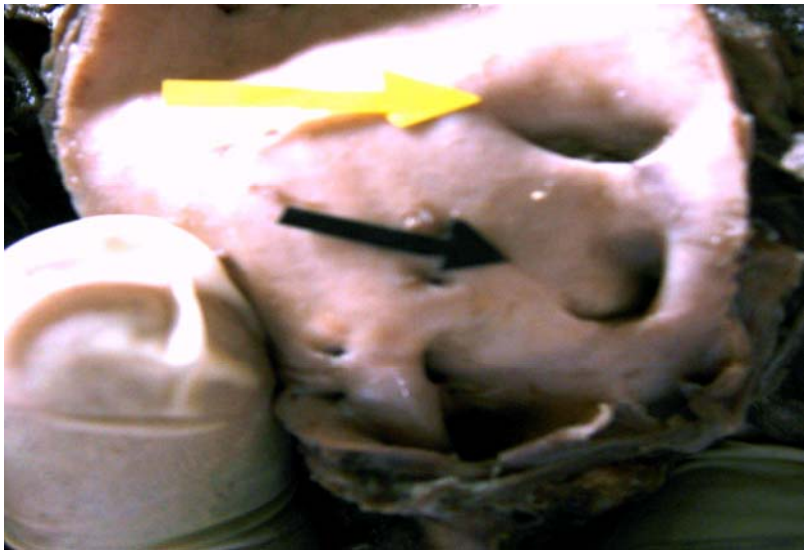


**Fig.3 (b). Luminal view of aorta: Same specimen showing two separate ostia for the origin of coeliac trunk above (yellow arrow) and common hepatic artery below (black arrow).**

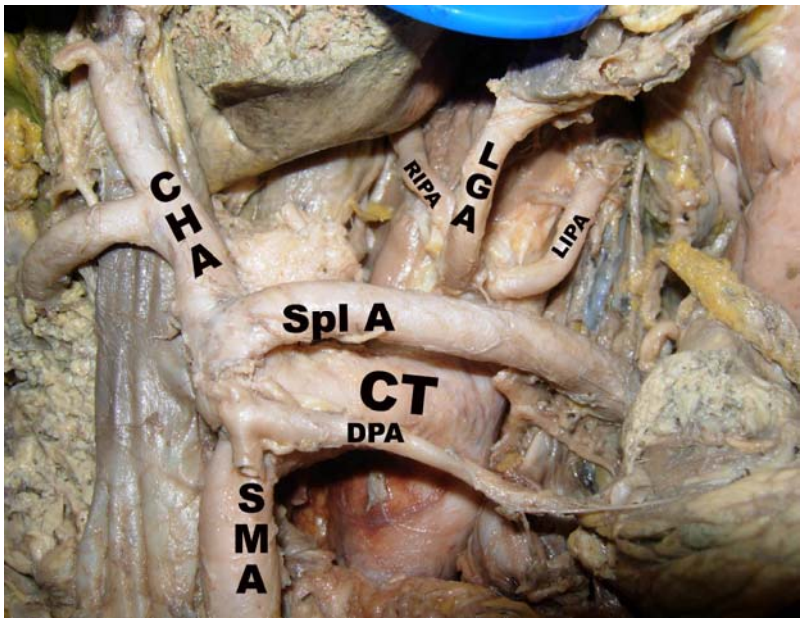



**Fig.4. Hepatolienomesenteric trunk with dorsal pancreatic artery. Gastrophrenic trunk from aorta.**

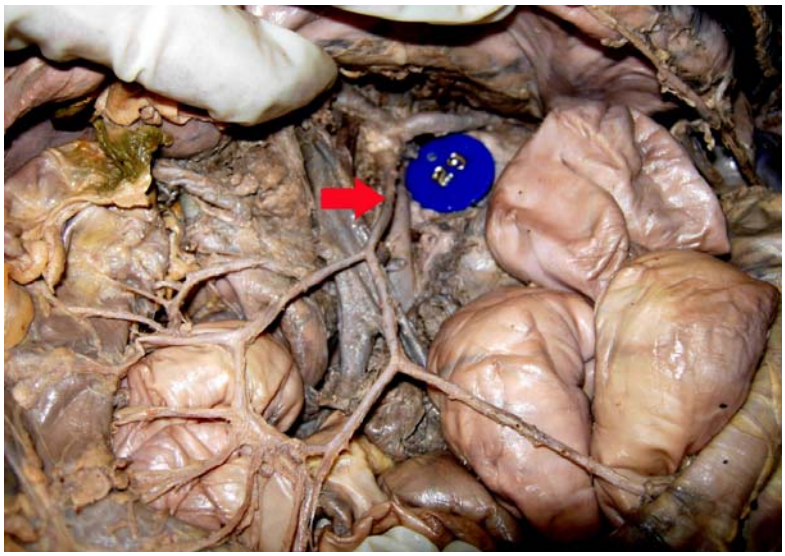


**Fig.5. Coeliaco-colic trunk. Middle colic artery from coeliac trunk.**

***(e) Coeliac trunk dividing into hepatic and splenic arteries:***

In one specimen, the coeliac trunk just divided into splenic artery and common hepatic artery. The left gastric artery took origin from the splenic artery (Fig.6).

**4. Complete and Incomplete coeliac trunk:**

Coeliac trunk giving origin to all the 3 branches i.e., left gastric, hepatic and splenic artery is known as complete trunk. Coeliac trunk without any of these 3 branches is known as incomplete coeliac trunk. In the present study, 96% of specimens had complete trunk and 4% of specimens had incomplete coeliac trunk (lienogastric & hepatolienomesenteric trunk) (Fig.3a,4), (Chart 2).

**5. Tripod of Haller:**

Coeliac trunk dividing into common hepatic, left gastric and splenic arteries simultaneously at a common point is known as Tripod of Haller. Such type of Tripod of Haller was observed in 19 specimens of the present study (Fig. 7).

**6. Supernumery Branches of Coeliac Trunk:**

In 24 specimens, supernumery branches from coeliac trunk were observed (Table 2), (Chart 3). The supernumery branches were:

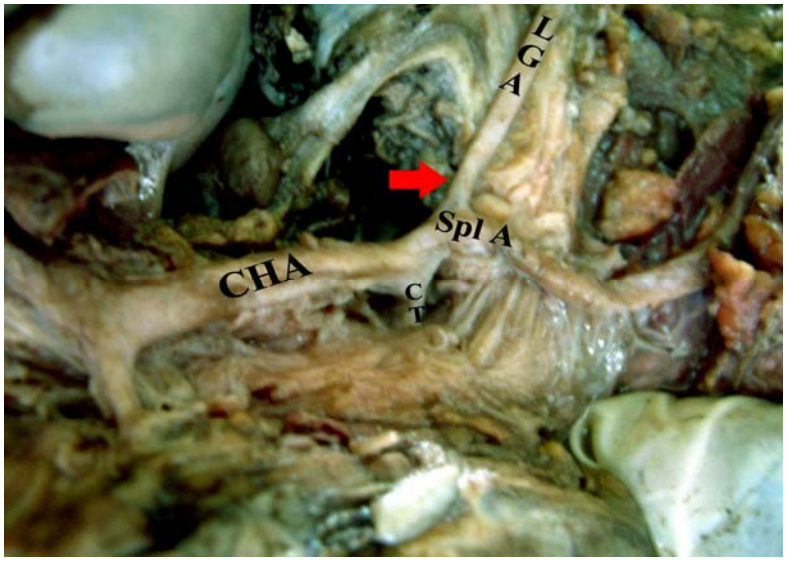



**Fig.6. Coeliac trunk dividing into hepatic artery and splenic artery. Left gastric artery took origin from splenic artery.**


**Fig.7. Hepatolienogastric trunk showing Tripod of Haller.**

## Chart – 2
## Complete and Incomplete Coeliac Trunk

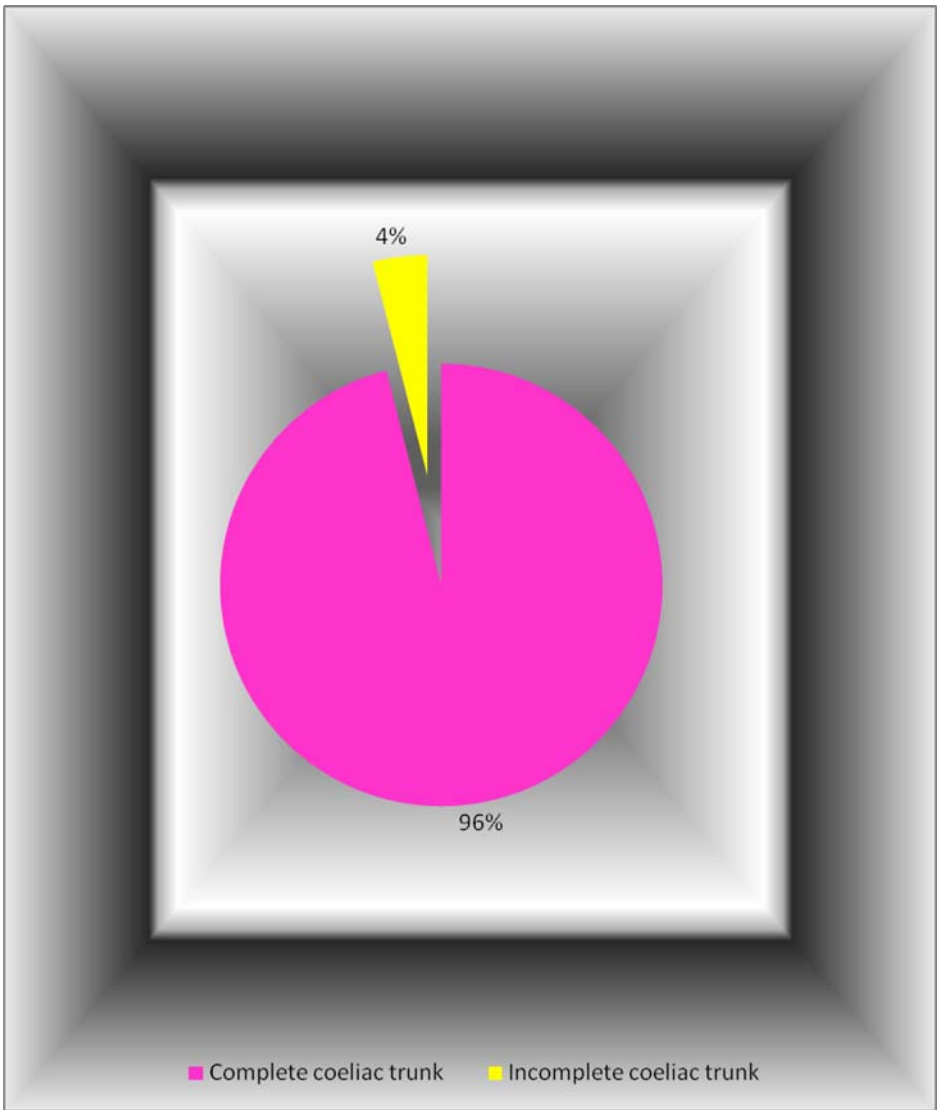
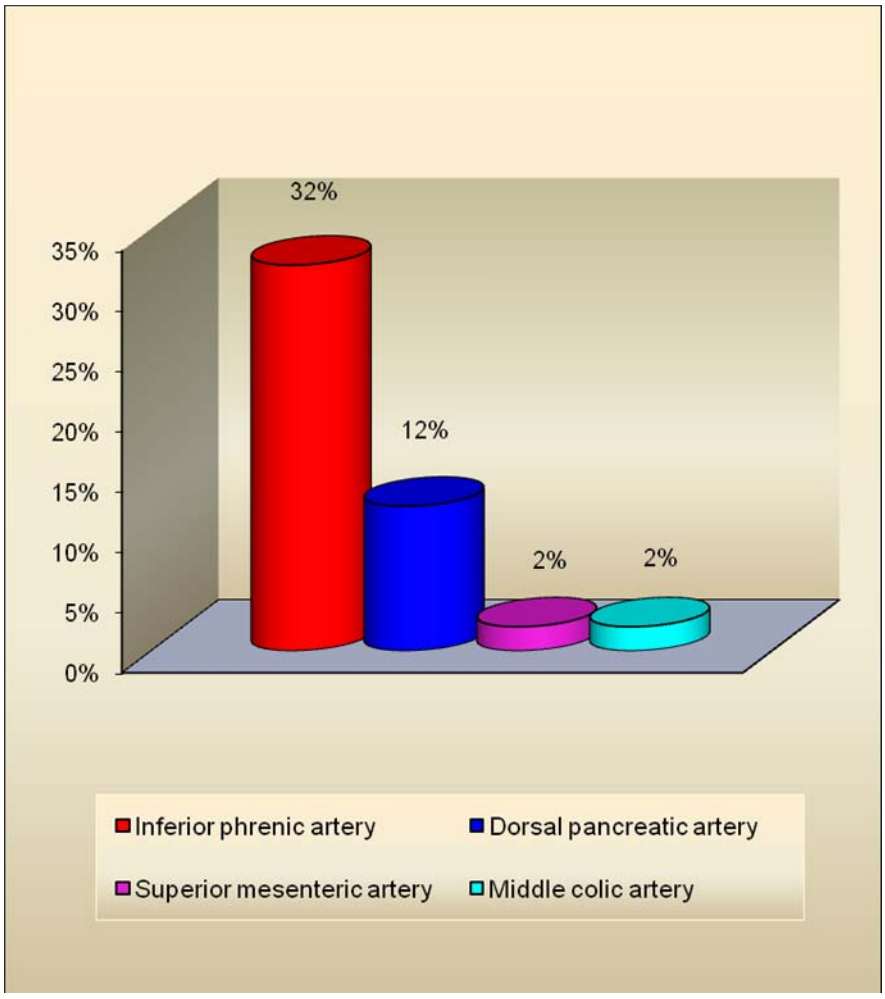


**Table - 2**
**Supernumery Branches from Coeliac Trunk**

| Sl.No | Name of the artery | No. of specimens | Percentage |
|---|---|---|---|
| 1. | Inferior phrenic artery | 16 | 32% |
| | a. *Left Inferior phrenic artery* | *10* | *20%* |
| | *b. Right Inferior phrenic artery* | *2* | *4%* |
| | *c. Both right and left inferior phrenic artery - separate origin* | *3* | *6%* |
| | *d. Both right and left inferior phrenic artery – origin from a common trunk* | *1* | *2%* |
| 2. | Dorsal pancreatic artery | 6 | 12% |
| 3. | Superior mesenteric artery | 1 | 2% |
| 4. | Middle colic artery | 1 | 2% |

## Chart - 3
## Supernumery Branches of Coeliac Trunk



***(a) Inferior phrenic artery:***

In 16 specimens, the inferior phrenic artery took origin from coeliac trunk. Out of these 16 specimens:

- In 10 specimens, the left inferior phrenic artery arose from coeliac trunk (Fig 8).
- In 2 specimens, the right inferior phrenic artery arose from coeliac trunk (Fig. 9).
- In 3 specimens, both right and left inferior phrenic arteries arose from coeliac trunk (Fig.10).
- In 1 specimen, coeliac trunk gave a common trunk which in turn divided into right and left inferior phrenic arteries (Fig.11).

***(b) Dorsal pancreatic artery:***

In 6 specimens, the origin of dorsal pancreatic artery from coeliac trunk was observed (Fig.12). In all the 6 specimens, the artery coursed posterior to the head of the pancreas and entered into the uncinate process.

***(c) Superior mesenteric artery:***

In one specimen, it took origin from coeliac trunk (Fig 4).

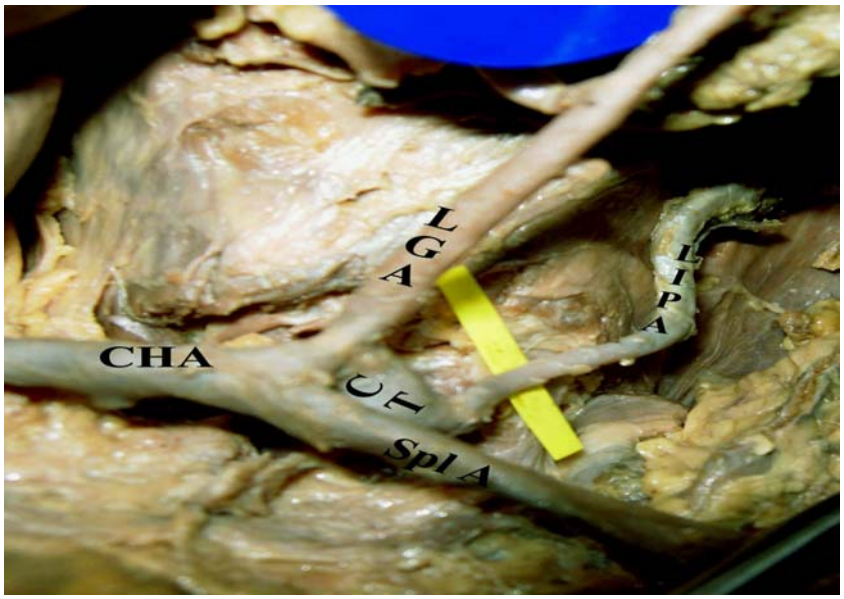



**Fig.8. Left inferior phrenic artery from coeliac trunk.**

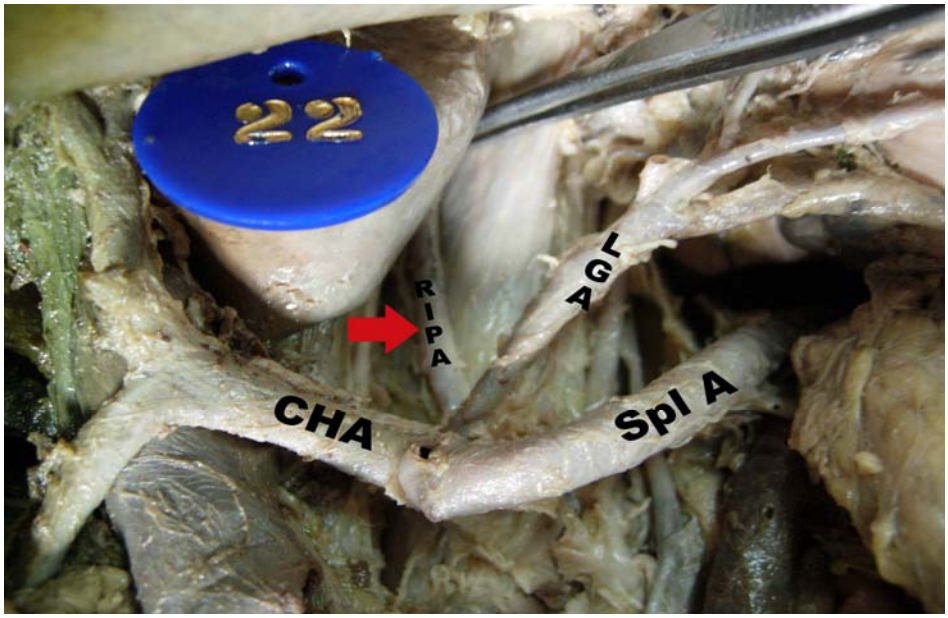



**Fig.9. Right inferior phrenic artery from coeliac trunk.**

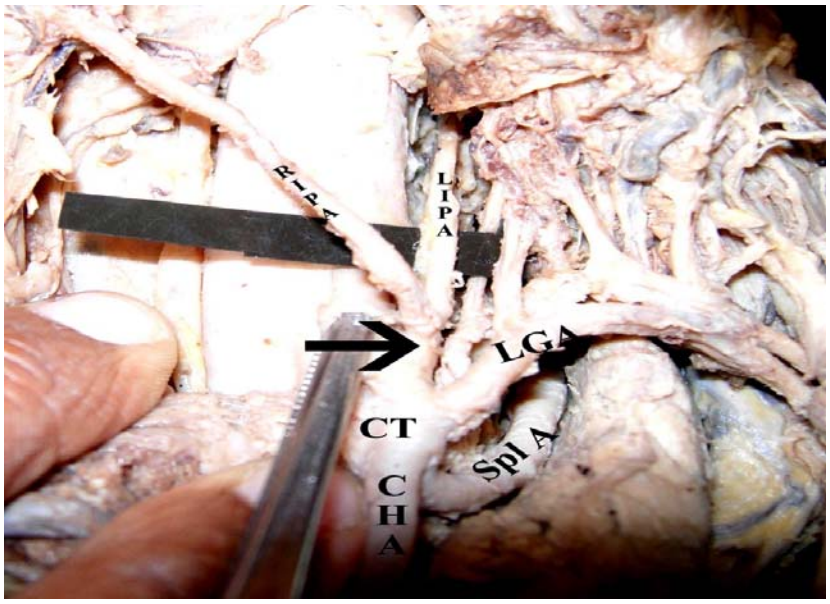



**Fig.10. Origin of both right and left inferior phrenic artery by a common trunk from the coeliac trunk.**

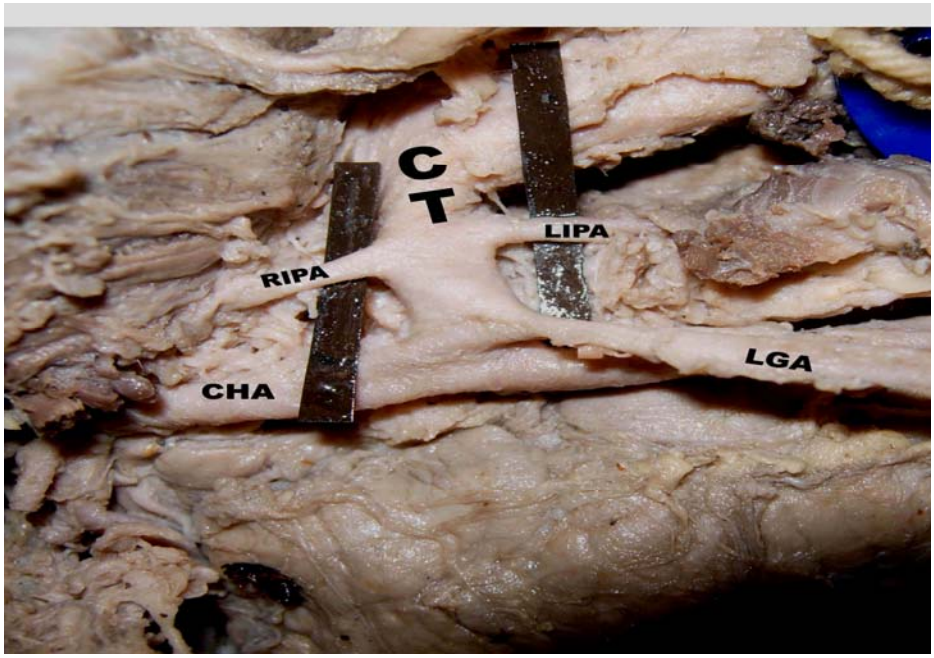



**Fig.11. Separate origin of both right and left inferior phrenic artery from coeliac trunk.**

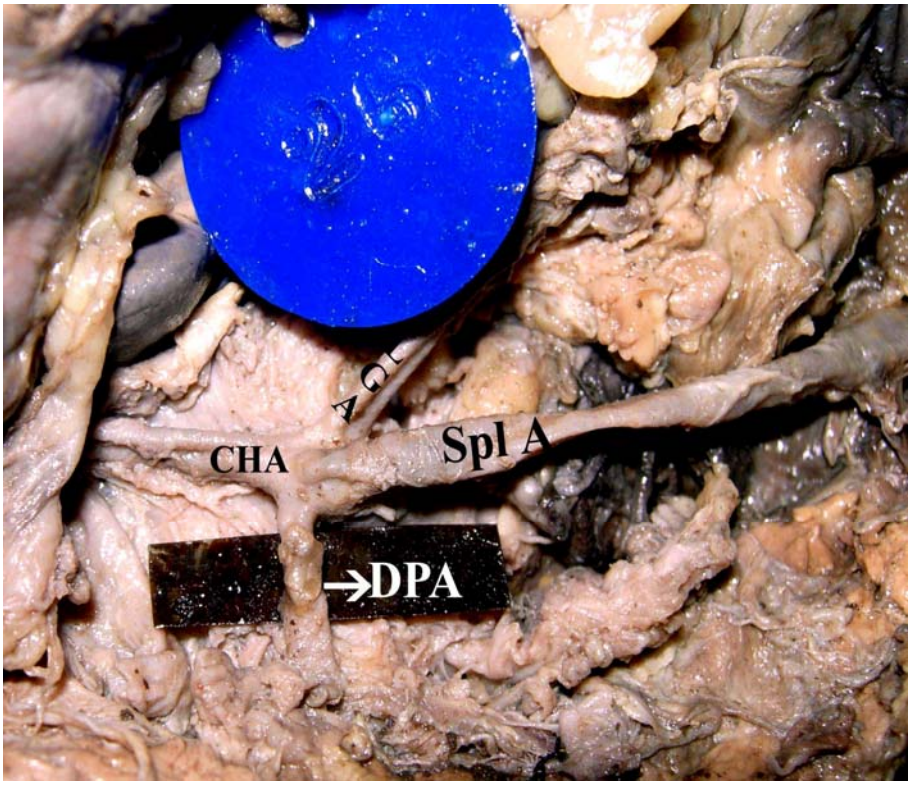



**Fig.12. Dorsal pancreatic artery from coeliac trunk.**

***(d) Middle colic artery:***

In one specimen, the middle colic artery took origin from coeliac trunk (Fig.5). It coursed in the transverse mesocolon and supplied the right two third of the transverse colon by its vasa recta.

**7. Length:**

The length of the coeliac trunk ranged from 1.1 to 2.3 cm. The number of specimens having variable length was tabulated (Table 3). The maximum number of specimens had the length ranged from 1.1 to 2.0 cm.

**Table 3**

**Length of the Coeliac Trunk**

| ***Length (cm)*** | ***No. of specimens*** |
|---|---|
| 1.0 to 1.5 | 24 |
| 1.6 to 2.0 | 22 |
| 2.1 to 2.5 | 4 |

**HEPATIC ARTERY AND ITS BRANCHES**

**1. Common hepatic artery:**

In 49 specimens, common hepatic artery arose from the coeliac trunk. In one specimen, it took replaced origin from abdominal aorta (Fig. 3a).

**2. Proper Hepatic Artery:**

Common hepatic artery after giving gastroduodenal artery ascended as proper hepatic artery which divided into right and left hepatic artery. This branching pattern was noticed in 36 specimens. In rest of the 14 specimens, the proper hepatic artery was not noted and the branching pattern differed as follows:

***(i) Trifurcation of Common Hepatic Artery:***

Out of 14 specimens, the common hepatic artery trifurcated in 4 specimens into gastroduodenal artery, right hepatic artery and left hepatic artery without the intervention of the proper hepatic artery (Fig.13).

***(ii) Continuation of common hepatic artery as right hepatic artery alone:***

In 2 specimens, the common hepatic artery after giving gastroduodenal artery, it just continued as right hepatic artery alone, without the intervention of the proper hepatic artery. In those 2 specimens, the left hepatic artery had replaced origin.

***(iii) Continuation of common hepatic artery as left hepatic artery alone:***

In 8 specimens, the common hepatic artery after giving gastroduodenal artery, it just continued as left hepatic artery alone,

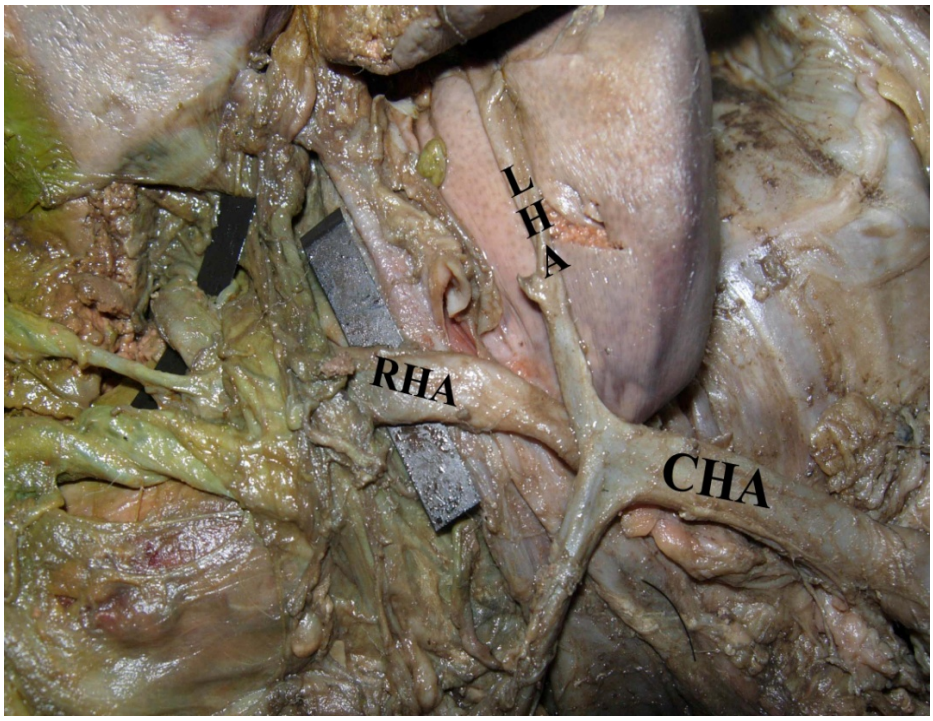



**Fig.13. CHA trifurcating as RHA, LHA & GDA without the intervention of proper hepatic artery.**

without the intervention of the proper hepatic artery. In those 8 specimens, the right hepatic artery had replaced origin.

**3. Right Hepatic Artery:**

The right hepatic artery took origin from proper hepatic artery in 37 specimens, from common hepatic artery in 4 specimens and in rest of the 9 specimens, it had replaced origin (Chart 4).

**4. Aberrant Right Hepatic Artery:**

Aberrant hepatic artery includes accessory and replaced hepatic arteries. In my study, aberrant right hepatic artery was noticed in 13 specimens, of which replaced right hepatic artery were seen in 9 specimens and accessory right hepatic artery were noticed in 4 specimens. The source of aberrant right hepatic arteries was noted as follows (Table 4):

***(a) Replaced right hepatic artery:***

Out of 9 specimens, the source of origin was as follows:

- In 5 specimens, it took origin from superior mesenteric artery (Fig 14).
- In 2 specimens, it took origin from gastroduodenal artery (Fig.15).
- In 1 specimen, two replaced right hepatic arteries took origin from superior mesenteric artery and gastroduodenal artery (Fig.16).

# Chart -4
# Origin of Right Hepatic Artery

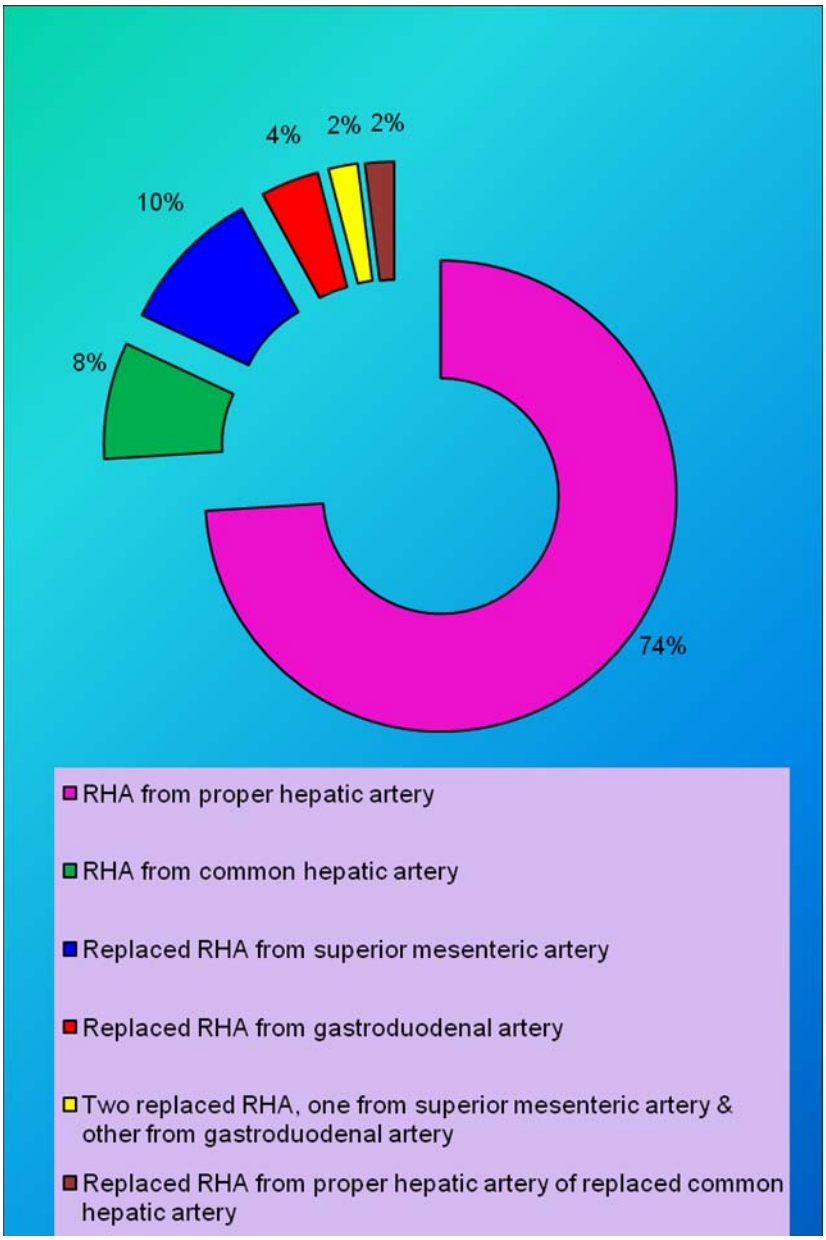


**Table - 4**
**Aberrant Right Hepatic Artery**

| ***Replaced Right Hepatic Artery*** | | | |
|---|---|---|---|
| **Sl. No** | **Origin** | **No. of specimens** | **Percentage** |
| 1. | Superior mesenteric artery | 5 | 10% |
| 2. | Gastroduodenal artery | 2 | 4% |
| 3. | Two replaced RHA from SMA and GDA | 1 | 2% |
| 4. | Replaced common hepatic artery | 1 | 2% |
| | **Total** | **8** | **16%** |
| ***Accessory Right Hepatic artery*** | | | |
| 1. | Gastroduodenal artery | 3 | 6% |
| 2. | Proper hepatic artery | 1 | 2% |
| | **Total** | **4** | **8%** |

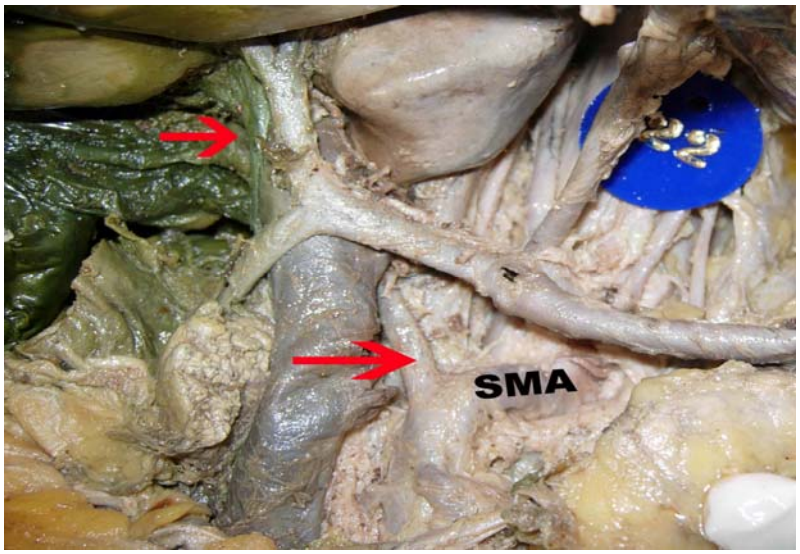



**Fig.14. Replaced RHA from superior mesentric artery, running posterior to the portal vein.**

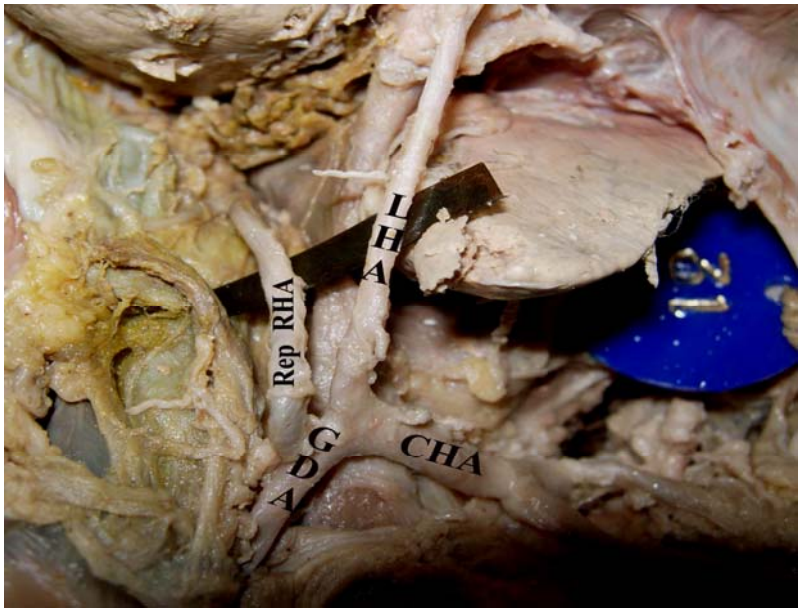



**Fig.15. Replaced RHA from gastroduodenal artery & CHA continuing as LHA.**

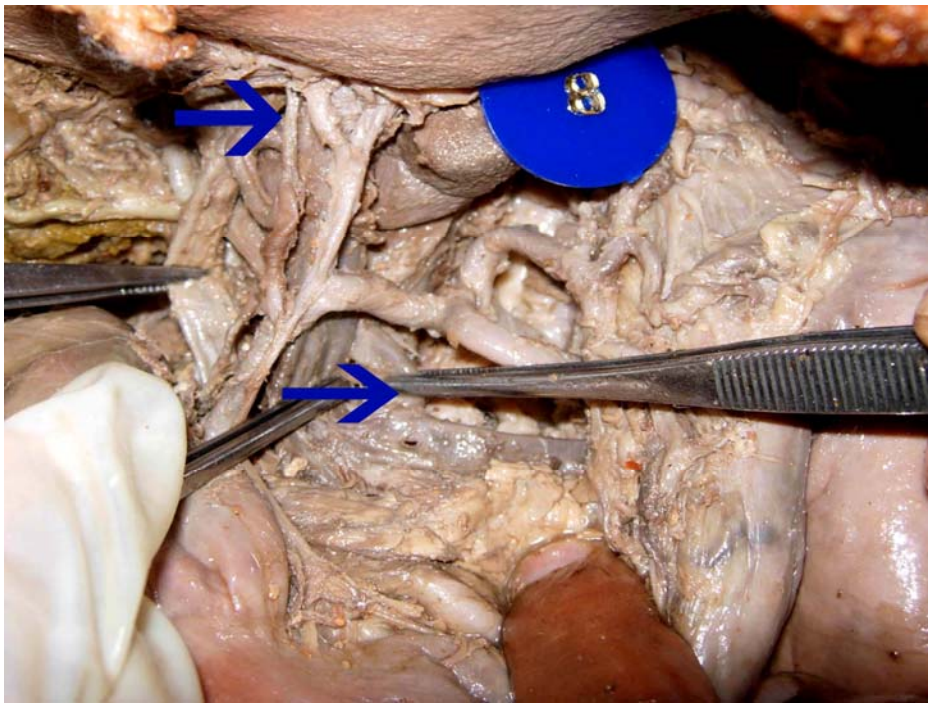



**Fig.16. Double replaced RHA from gastroduodenal artery & superior mesentric artery.**

- In 1 specimen, it took origin from proper hepatic artery of replaced common hepatic artery.

The replaced right hepatic artery of superior mesenteric artery origin, in all the above 6 specimens, ran unusually posterior to the head of the pancreas and ascended posterior to the portal vein in the right free margin of the lesser omentum (Fig.14).

***(b) Accessory right hepatic artery:***

Out of 4 specimens, the source of origin was as follows:

- In 3 specimens, it took origin from gastroduodenal artery (Fig 17).
- In 1 specimen, it took origin from proper hepatic artery (Fig 18).

**5**. **Left Hepatic Artery:**

The left hepatic artery took origin from proper hepatic artery in 43 specimens, from common hepatic artery in 4 specimens and in the rest of the 3 specimens, it had replaced origin (Chart 5).

**6. Aberrant Left Hepatic Artery:**

In 3 specimens, aberrant left hepatic artery was observed (Table 5). All were replaced left hepatic artery, out of which,

- In 2 specimens, the replaced left hepatic artery took origin from left gastric artery (Fig.19).

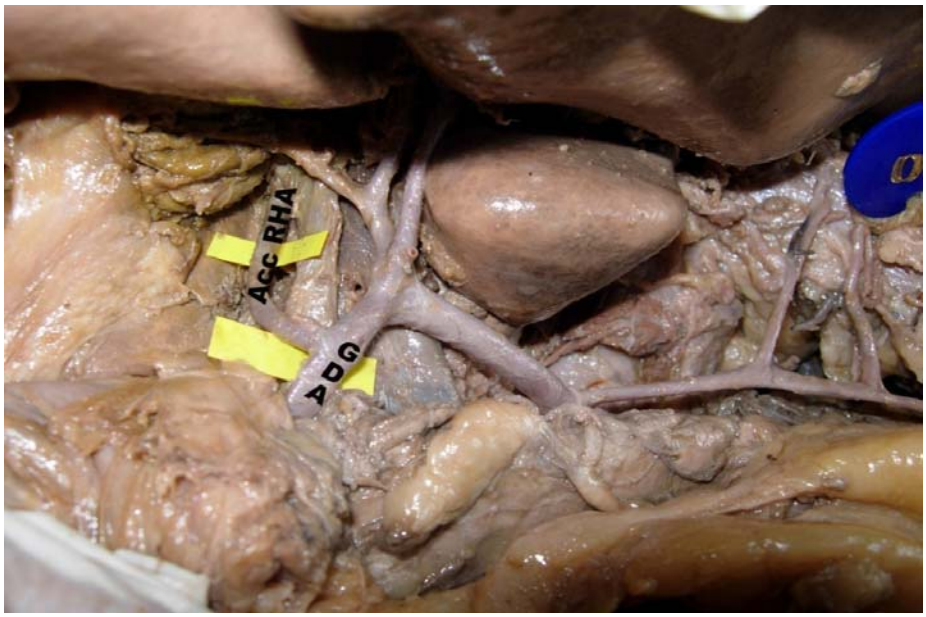



**Fig.17. Accessory RHA from gastroduodenal artery.**

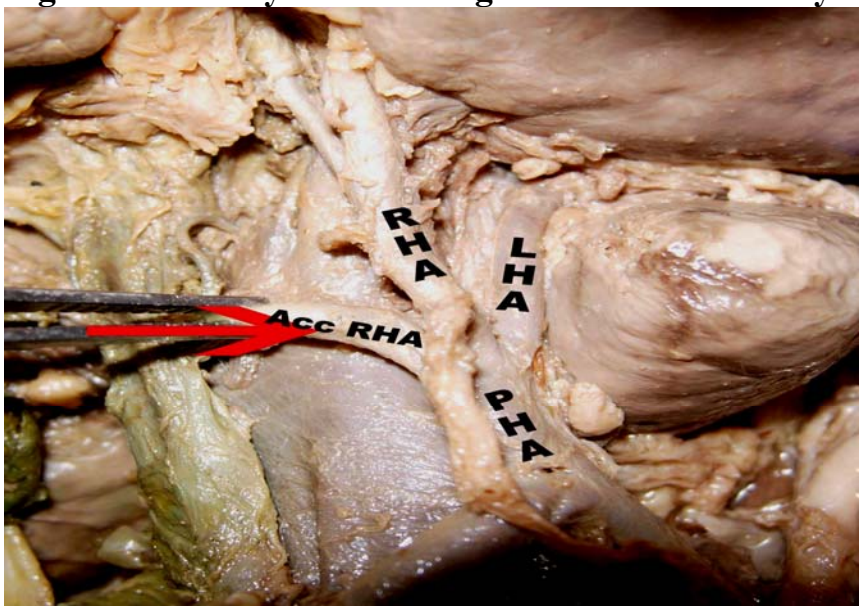



**Fig.18. Accessory RHA from proper hepatic artery.**

**Chart - 5**
**Origin of Left Hepatic Artery**

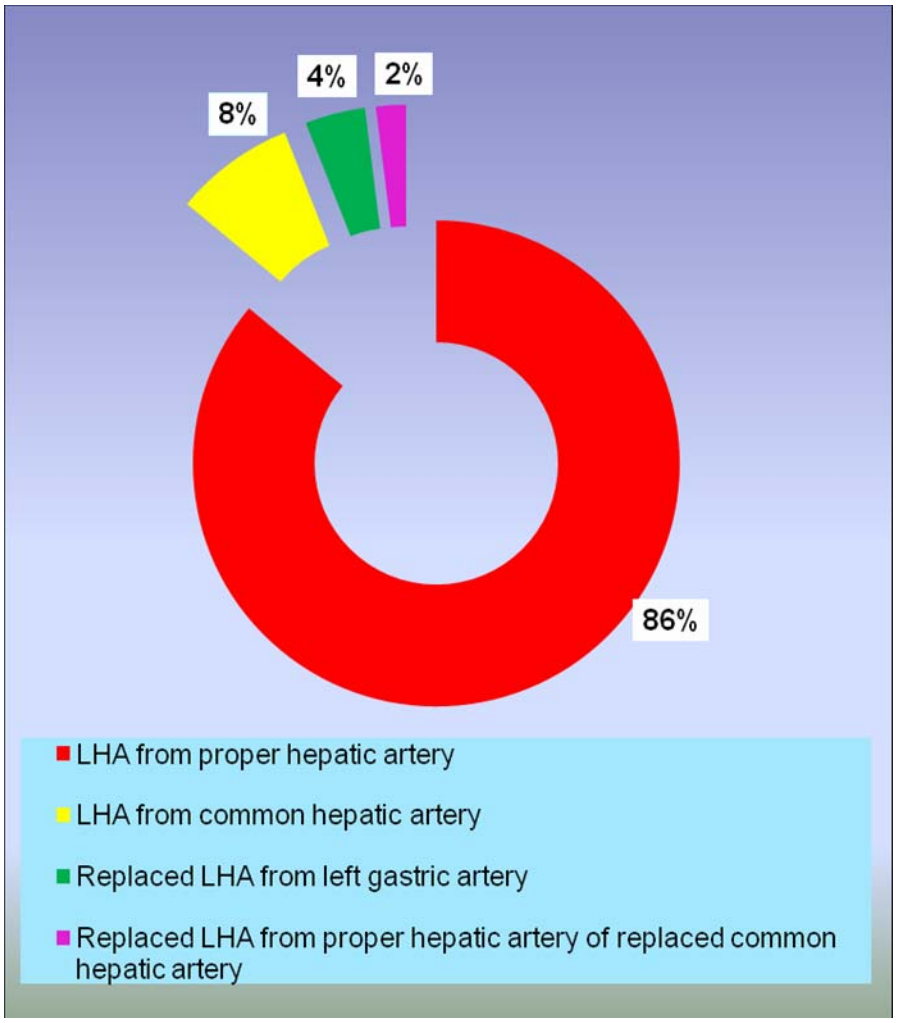


**Table – 5**
**Aberrant Left Hepatic Artery**

| ***Replaced Left Hepatic Artery*** | | | |
|---|---|---|---|
| **Sl. No** | **Origin** | **No. of specimens** | **Percentage** |
| 1. | Left gastric artery | 2 | 4% |
| 2. | Replaced common hepatic artery | 1 | 2% |
| | **Total** | **3** | **6%** |

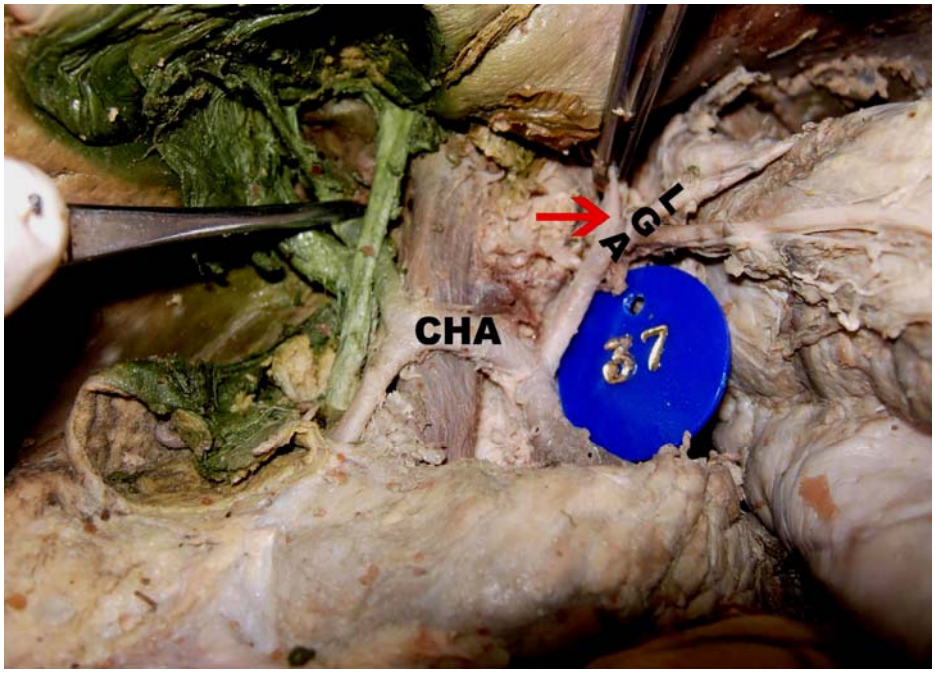



**Fig.19. Replaced LHA from left gastric artery. PHA continuing as RHA only.**

- In 1 specimen, it took origin from the proper hepatic artery of replaced common hepatic artery.

**7. Middle Hepatic Artery:**

In 31 specimens, middle hepatic artery was seen. Out of which,

- In 16 specimens, it took origin from right hepatic artery (Fig 20).
- In 11 specimens, it took origin from left hepatic artery (Fig 21).
- In 4 specimens, it took origin from proper hepatic artery (Fig 22).

**8. Other Branches of Hepatic Artery:**

***(a) Gastroduodenal Artery:***

In all the 50 specimens, it took origin from common hepatic artery. Among these 50 specimens, in 1 specimen, it took origin from the common hepatic artery of aortic origin. In all the specimens, it gave right gastroepiploic artery that run along the greater curvature of the stomach.

- In 3 specimens, it gave origin to replaced right hepatic artery (Fig 15).
- In another 3 specimens, it gave origin to the accessory right hepatic artery (Fig 18).


**Fig 20. Middle hepatic artery from right hepatic artery.**

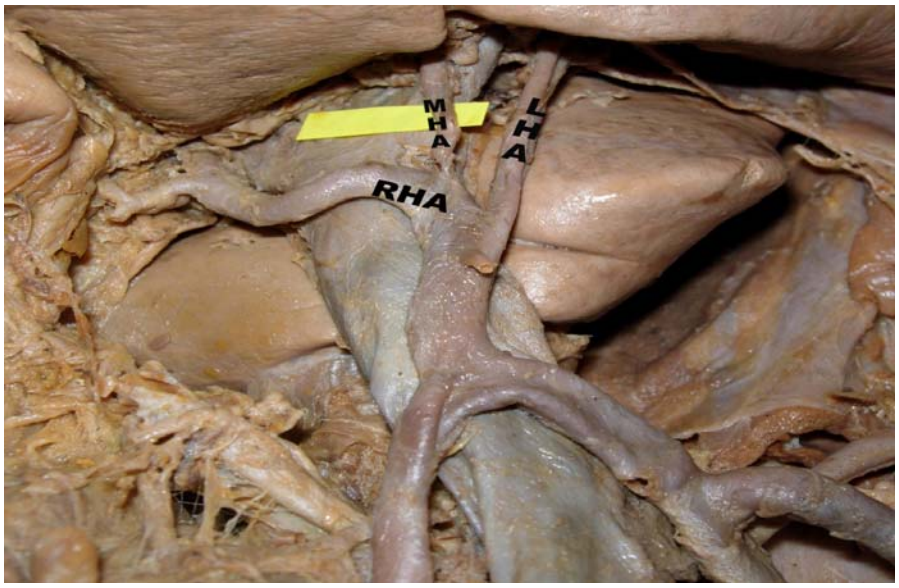



**Fig.21. Middle hepatic artery from left hepatic artery**

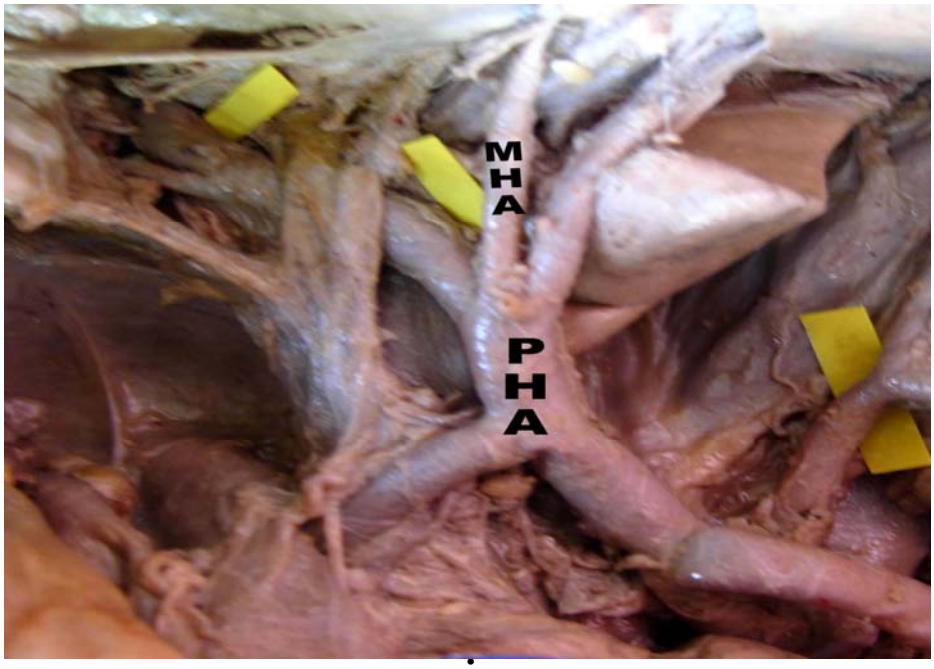



**Fig.22. Middle hepatic artery from proper hepatic artery**

***(b) Right Gastric Artery:***

The origin of right gastric artery was observed as follow as:

- From proper hepatic artery in 25 specimens (Fig. 23).
- From left hepatic artery in 15 specimens (Fig. 24).
- From gastroduodenal artery in 6 specimens (Fig. 25).
- From right hepatic artery in 3 specimens (Fig. 26).
- From common hepatic artery in 1 specimen.

***(c) Cystic artery:***

The origin of cystic artery was observed as:

- In 39 specimens, it took origin from right hepatic artery.
- In 10 specimens, it took origin from aberrant right hepatic artery. Out of which in one specimen, two cystic arteries arose separately from the two replaced right hepatic artery of gastroduodenal artery and superior mesenteric artery (Fig. 25).
- In 1 specimen, it took origin from gastroduodenal artery (Fig. 27).

**SPLENIC ARTERY:**

**1. Origin:**

In all the 50 specimens, it took origin from the coeliac trunk.

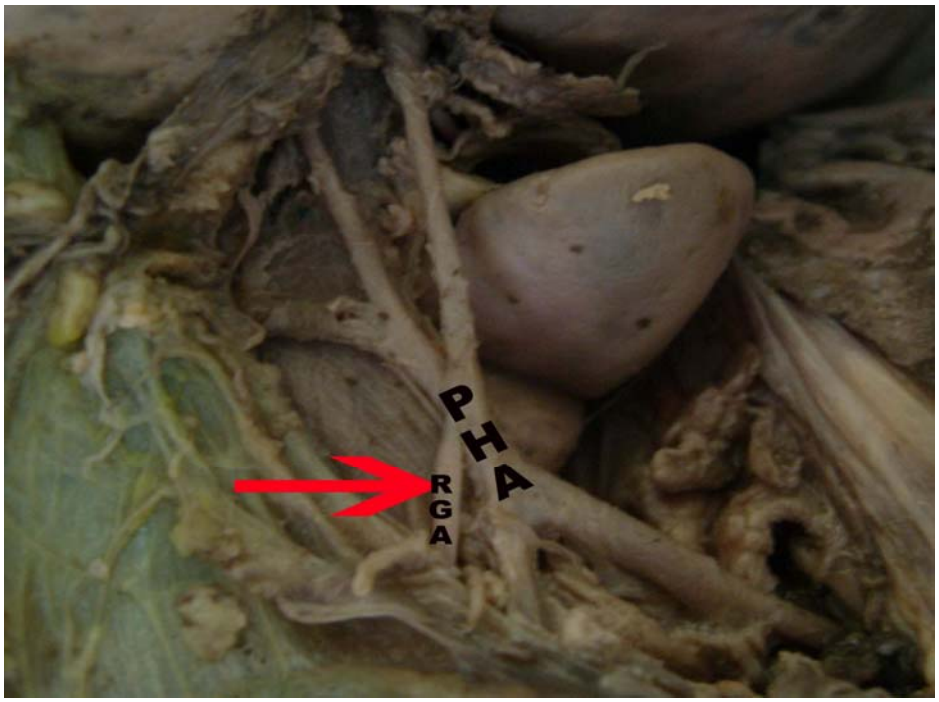



**Fig. 23. Right gastric artery from Proper hepatic artery.**

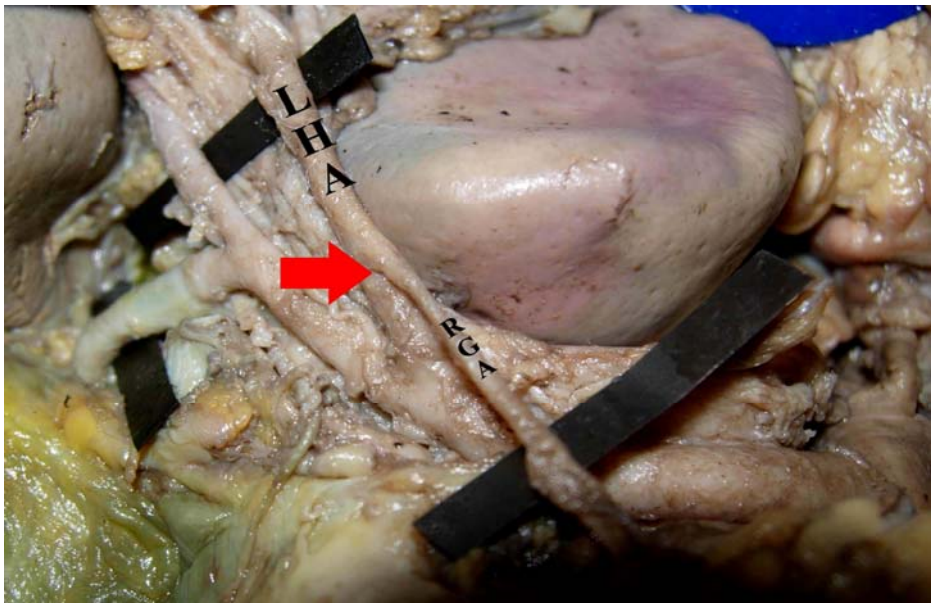



**Fig.24. Right gastric artery from LHA.**

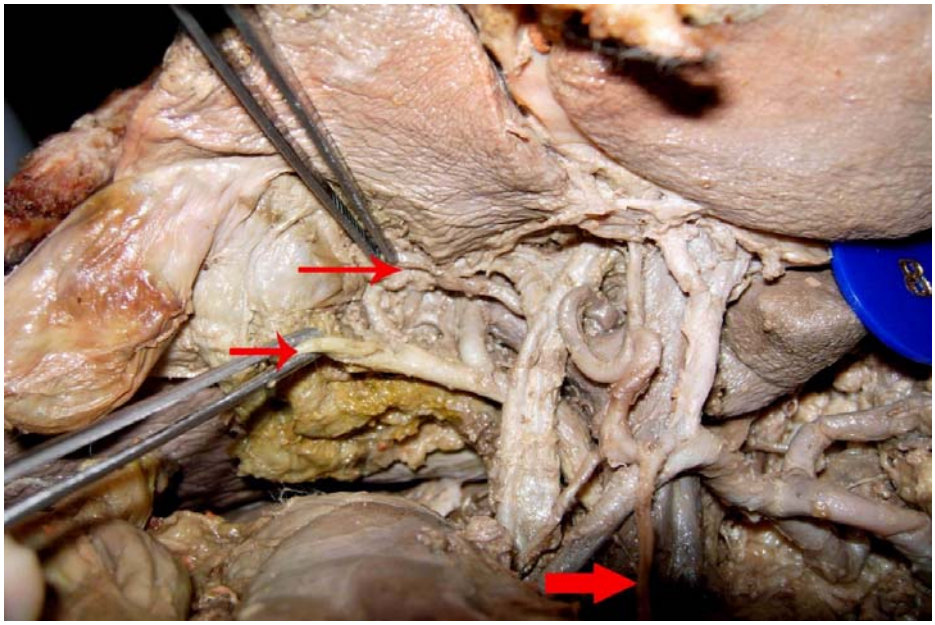


**Fig.25. Two cystic arteries from replaced RHA of GDA & replaced RHA of SMA origin. RGA from GDA.**

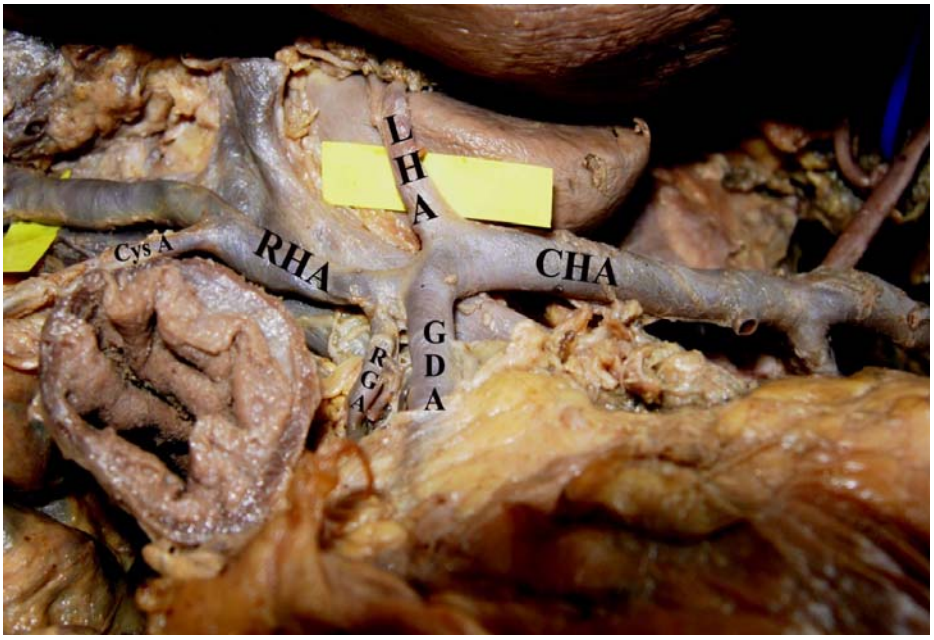



**Fig.26. Origin of RGA from RHA. Trifurcation of CHA into RHA, LHA & GDA.**

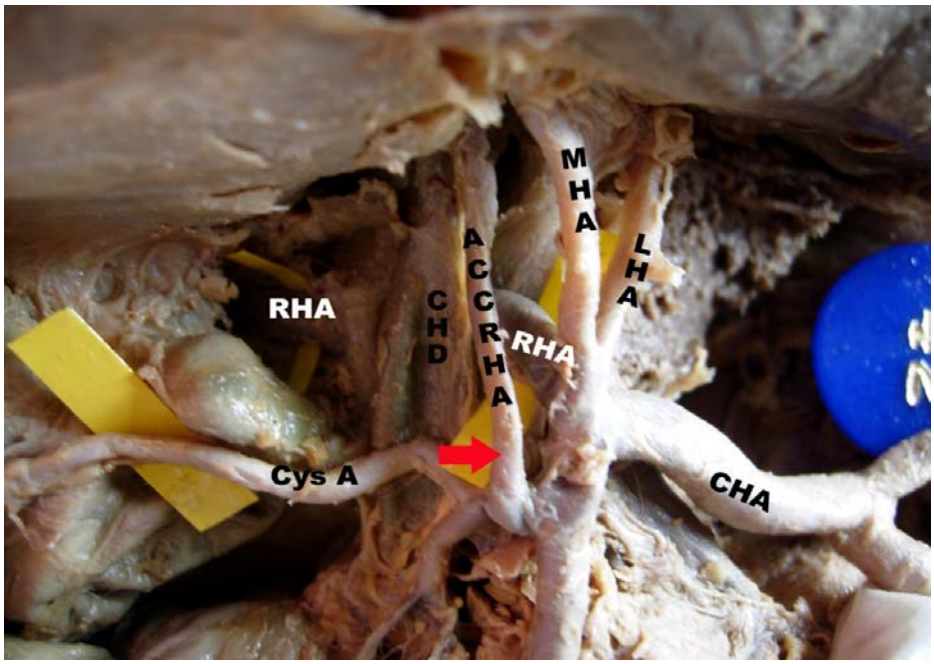



**Fig.27. Accessory RHA & cystic artery from gastroduodenal artery.**

**2. Length:**

The length of the splenic artery ranged from 8 cm to 13.5 cm. Its mean length was 9.11 cm. The number of specimens having variable length was tabulated (Table 6).

**Table 6**

***Length of the Splenic Artery***

| ***Length (cm)*** | ***No. of specimens*** |
|---|---|
| 8.0 to 10.0 | 26 |
| 10.1 to 12.0 | 18 |
| 12.1 to 13.5 | 6 |

**3. Tortuosity Index:**

Splenic artery is famous for its tortousity. In some specimens, it was highly tortuous and in few it was almost straight. The ratio of the curved length of the splenic artery to its straight distance from its origin to the point of commencement of hilar branches is called as tortuosity index**.** It ranged from 1.02 to 1.29.

**2.Relation with the Pancreas:**

The course of splenic artery is usually along the upper border of the pancreas. This usual supra-pancreatic course was noticed in 38

specimens (Fig. 28). In 10 specimens, it passed behind the pancreas (Fig. 29). In 2 specimens, it passed inside the substance of pancreas (Fig. 30).

**2. Branches:**

In all the specimens, the usual branches of splenic artery such as pancreatic branches, short gastric arteries, and the left gastroepiploic artery were observed. The artery terminated by dividing into two or more splenic branches that entered into the hilum of the spleen. Apart from these usual branches, some of the peculiar branches were noted. They were:

***(a) Polar Arteries:***

A separate branch from the splenic artery was observed to enter into the superior or inferior poles according to which they are named as superior polar artery and inferior polar artery respectively. In the present study,

- Superior polar artery was observed in 15 specimens (Fig.31).
- Inferior polar artery was observed in 18 specimens (Fig.32).
- Both superior and inferior polar arteries were observed in 4 specimens (Fig.33).


**Fig.28. Splenic artery running along the upper border of pancreas.**

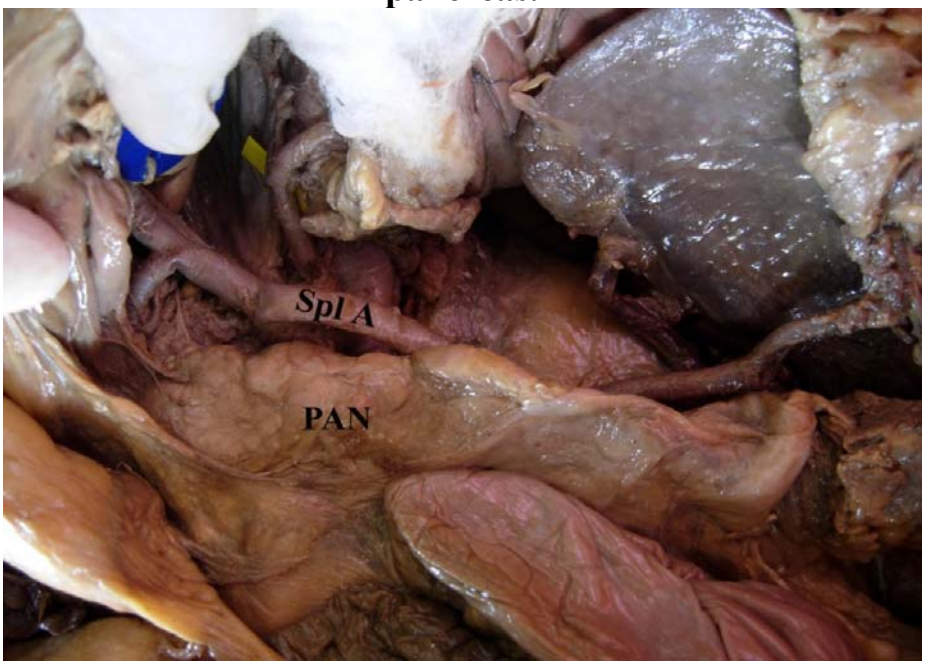



**Fig.29.Retropancreatic course of splenic artery.**

**Fig 30. Intrapancreatic course of splenic artery.**

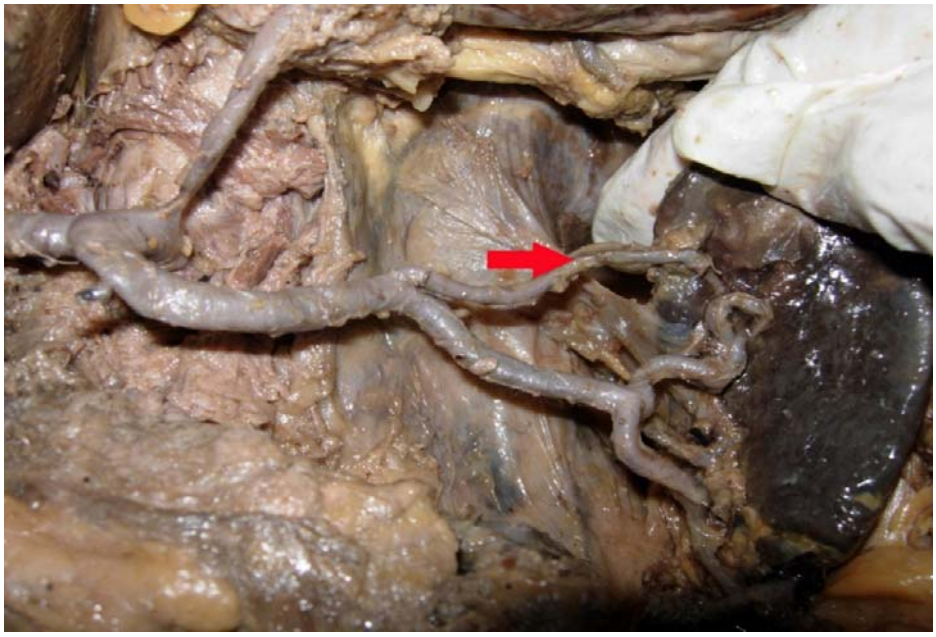


**Fig.31.Superior polar artery from splenic artery.**

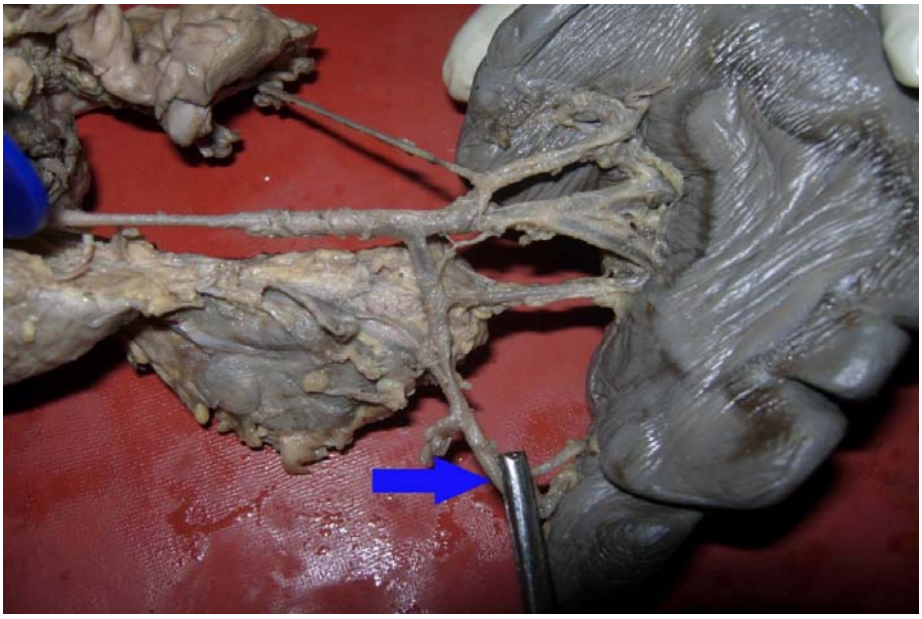


**Fig.32. Inferior polar artery from splenic artery.**

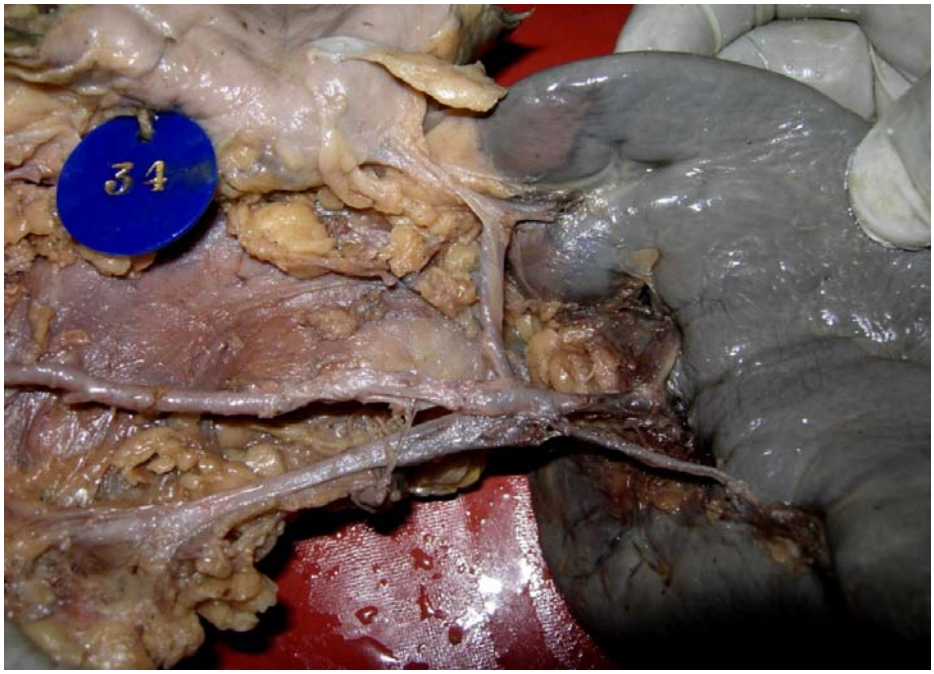



**Fig.33. Superior and inferior polar artery.**

***(b) Dorsal pancreatic artery:***

In 9 specimens, dorsal pancreatic artery took origin from the proximal few centimeter of origin of the splenic artery (Fig.34).

***(c) Posterior gastric artery:***

In 14 specimens, the posterior gastric artery took origin from the middle of the splenic artery and it coursed upwards to enter into the posterior surface of the stomach (Fig.35).

***(d) Gastrosplenic artery:***

In 12 specimens, the gastrosplenic artery took origin from the splenic artery. This artery divided into two branches, one entered into the posterior surface of the stomach and the other entered into the inferior pole of the spleen (Fig.36). This artery is considered to be the intermediate type between posterior gastric artery and inferior polar artery.

***(e) Left Gastric Artery:***

In one specimen, the left gastric artery took origin from the splenic artery (Fig.6).

***(f) Accessory Splenic Artery:***

In 1 specimen, an inferior polar branch which was given off from the very proximal segment of splenic artery ran very parallel to the later as an accessory splenic artery entered into the inferior pole of the spleen (Fig 37).

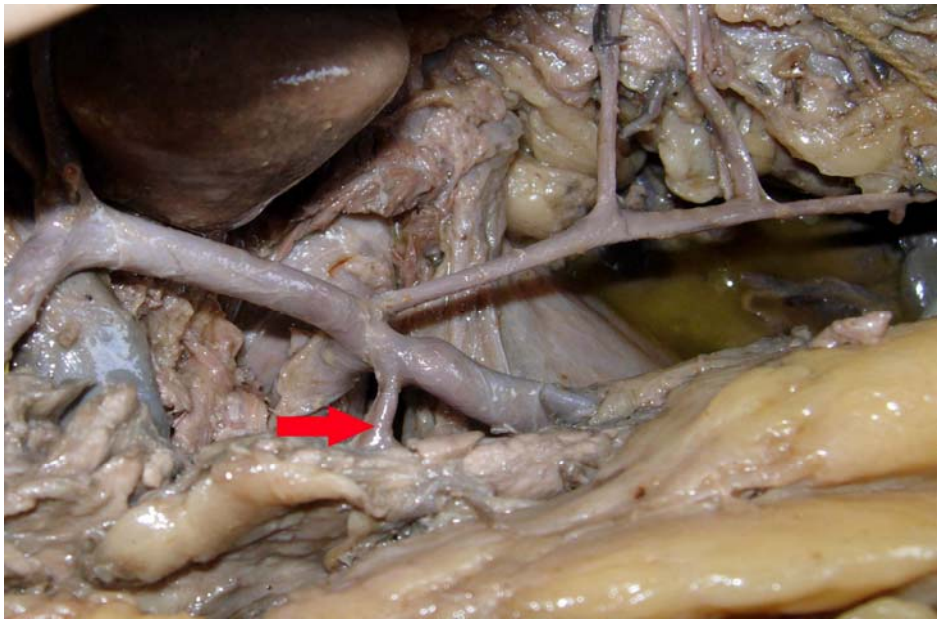


**Fig 34. Dorsal pancreatic artery from splenic artery.**

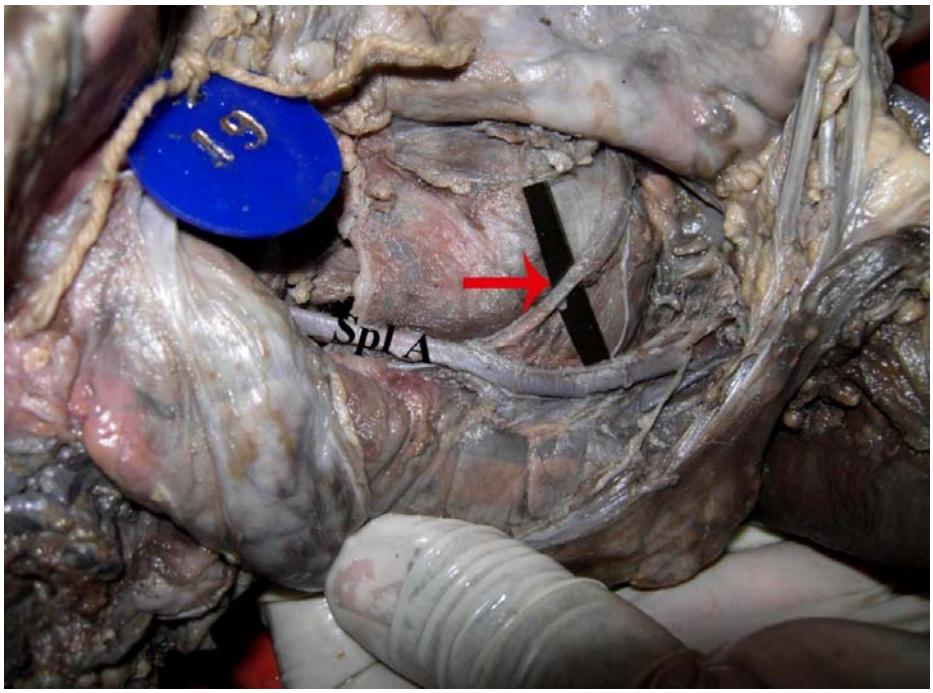



**Fig.35. Posterior gastric artery from splenic artery.**

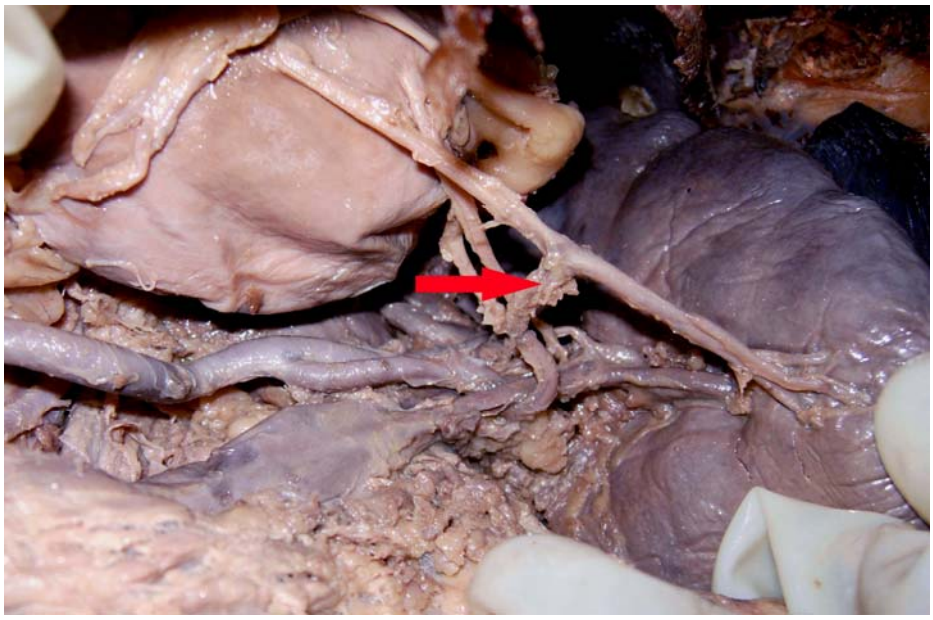


**Fig 36. Gastrosplenic artery dividing into 2 branches to supply the posterior surface of stomach & inferior pole of spleen.**


**Fig.37. Accessory splenic artery running as inferior polar artery parallel to splenic artery.**

***(g) A branch to the Accessory Spleen:***

In 1 specimen, a branch from the splenic artery supplied an accessory spleen which was present in the lienorenal ligament (Fig.38).

**LEFT GASTRIC ARTERY**

**1. Origin:**

In 48 specimens, it took origin from the coeliac trunk. In one specimen, it took origin directly from the aorta, a little above the origin of coeliac trunk as Gastrophrenic Trunk, which gave both right and left inferior phrenic arteries (Fig.4). In another one specimen, it took origin from the splenic artery (Fig.6).

**2. Division and Distribution:**

In one specimen, the artery divided into two branches at proximal few centimeters of its origin as an anterior and posterior branch to supply the respective surfaces of the stomach (Fig 39).

**3. Supernumery Branches:**

Apart from the gastric and oesophageal branches, the left gastric artery gave following supernumery branches.

***(a) Inferior Phrenic Artery:***

In 2 specimens, the inferior phrenic artery took origin from the left gastric artery.

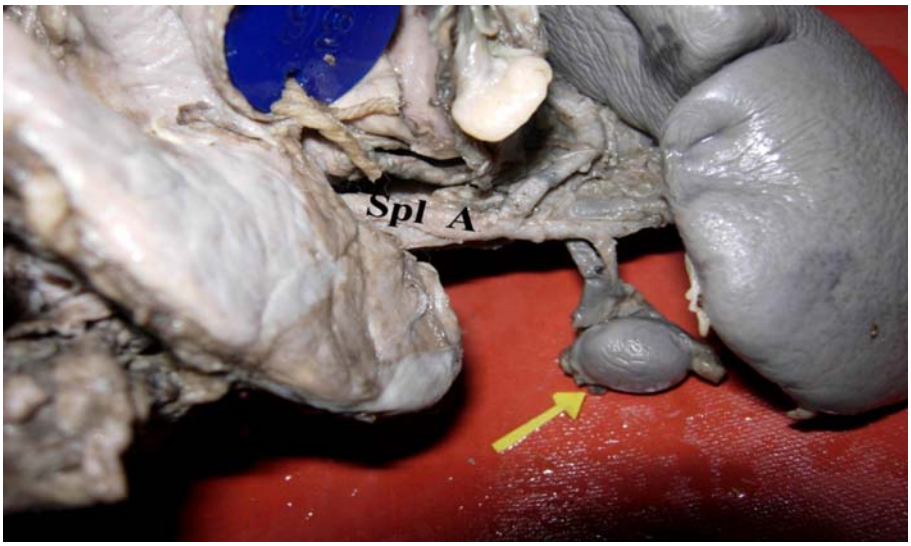



**Fig.38. Splenic artery giving a branch to accessory spleen.**

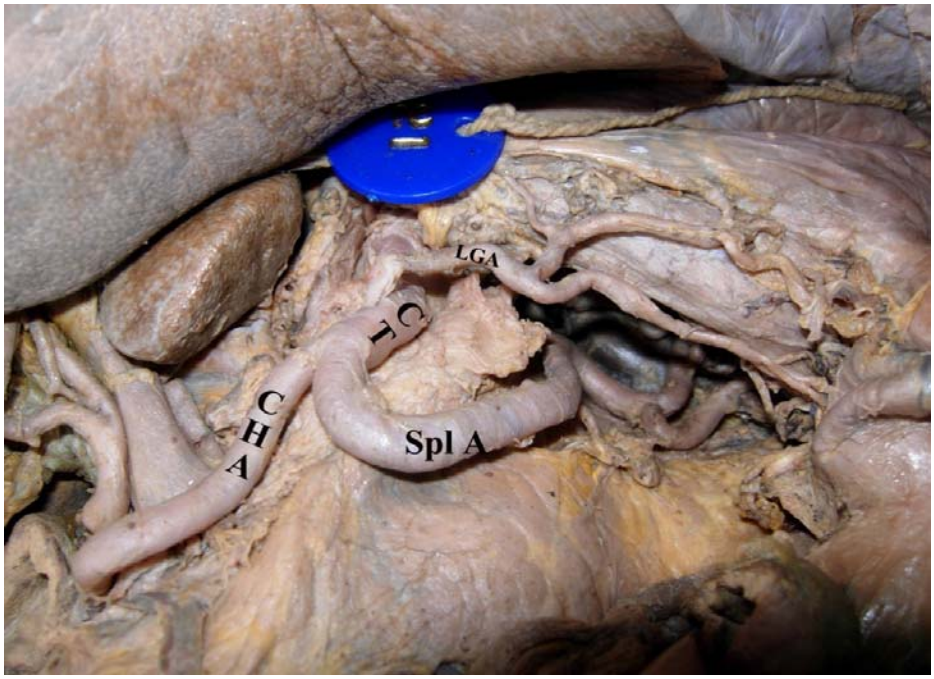



**Fig.39.LGA divided into two branches that supply anterior and posterior surfaces of the stomach.**

- In 1 specimen, the left gastric artery gave origin to left inferior phrenic artery (Fig. 40).
- In 1 another specimen, the left gastric artery taking origin from aorta gave both right and left inferior phrenic arteries as Gastrophrenic trunk (Fig. 4).

***(b) Replaced Left Hepatic Artery:***

In 2 specimens, the left gastric artery gave replaced left hepatic artery (Fig. 19).

**Radiological Study**

Apart from 50 cadaveric specimens, radiological study was done in 1 patient, which was not included in the present study. The CT angiogram & reconstructed volumetric 3D rendered angiogram was done. The origin of the coeliac trunk and its branches were observed to be normal (Fig 41, 42, 43).


**Fig 40. Left inferior phrenic artery from left gastric artery.**


**Fig.41 Axial section of CT angiogram showing origin of coeliac trunk from aorta.**

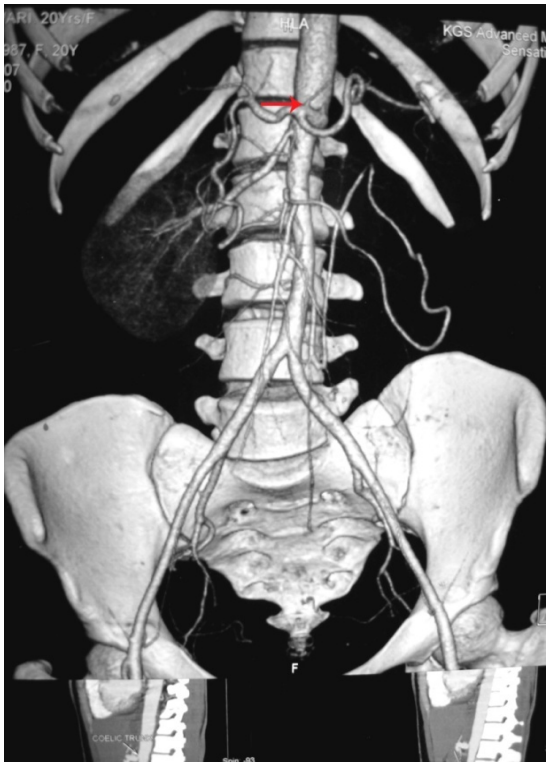


**Fig.42**
**Reconstructed volumetric 3D rendered CT angiogram in AP projection showing origin of coeliac trunk and its branches.**

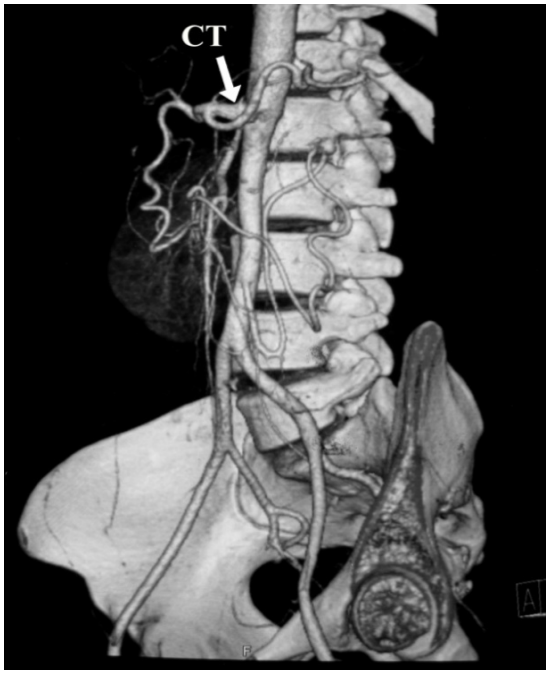



**Fig.43**
**Reconstructed volumetric 3D rendered CT angiogram in sagital projection showing origin of coeliac trunk and its branches.**

# *DISCUSSION*

# DISCUSSION

The anatomy of coeliac trunk and its branches studied in 50 specimens were compared with the previous studies.

## COELIAC TRUNK

### 1. Origin:

In the textbook of Gray's Anatomy, it was stated that the coeliac trunk is the ventral branch of the aorta dividing into the left gastric, common hepatic and splenic arteries. In my study also the coeliac trunk took origin from the ventral surface of the aorta in all the 50 specimens.

Rossi (1904), Piquand (1910), Yamaki *et al* (1995), Higashi N *et al* (1995) Basar *et al* (1995), Marakami T *et al* (1998) Peschaud F et (2006) had noticed absence of coeliac trunk and all the three branches took separate origin from aorta. But in the present study, coeliac trunk was not absent in any of the 50 specimens.

### 2. Direction of Inclination:

Vandamme JP Bonte J (1985) observed the inclination of coeliac trunk unusually to the left is due to absence of the pull exerted by coeliacal hepatic artery. In the present study, the above finding was observed in 1 specimen.

**3. Pattern:**

The various pattern of coeliac trunk were: (Table 7), (Chart 6)

***a) Hepatolienogastric Trunk:***

Lipshutz (1917) had observed this type of trunk in 75% out of 83 cadavers, Adachi (1928) in 87.7% out of 252 specimens, Michels (1955) in 89% out of 200 specimens, Shoumura S *et al* (1991) in 90.2% out of 184 specimens. In my study, its incidence is 92% out of 50 specimens, which is closely similar to Shoumura S *et al* study.

***b) Lienogastric Trunk*:**

Lipshutz (1917) found this type in 4% specimens, Michels (1955) in 2%, Shoumura S *et al* (1991) in 1.09% of specimens. In the current study, it was noticed in 1 specimen – 2% incidence, which is similar to Michels study.

***c) Hepatolienomesenteric Trunk:***

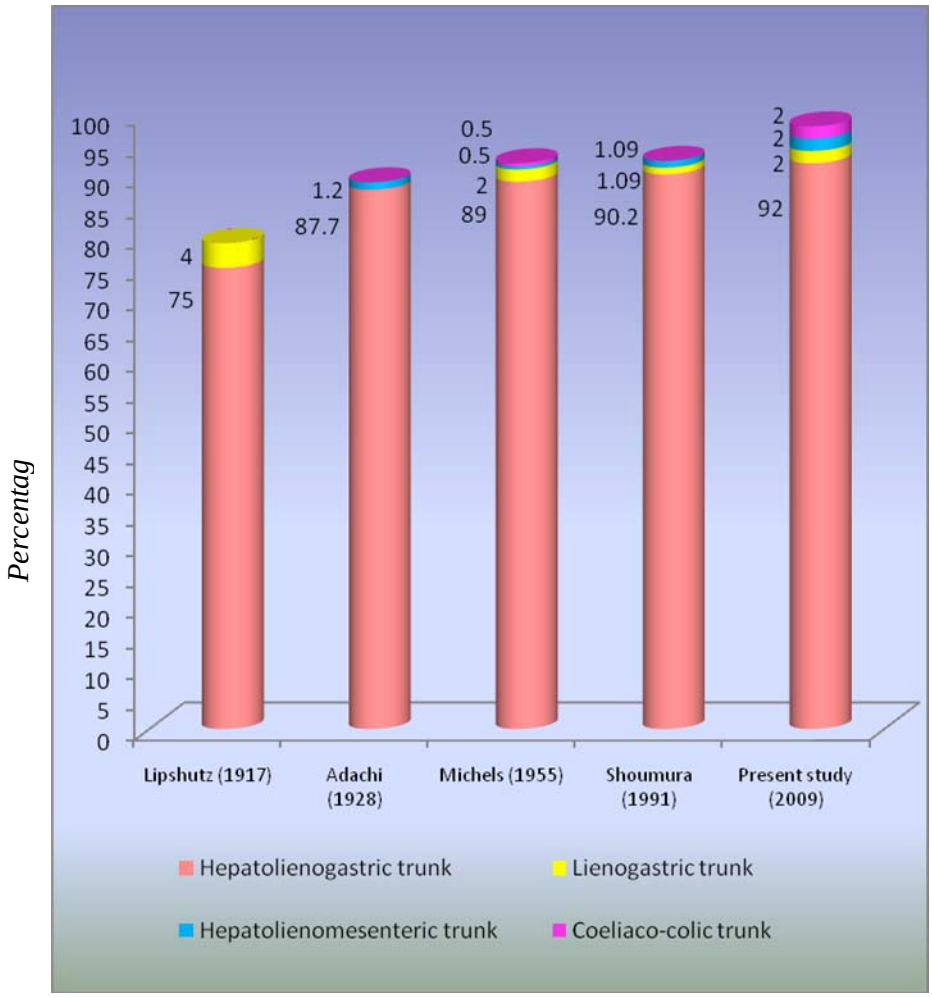
This type of trunk had been reported by Adachi (1928) in 1.2%, Michels (1955) in 0.5%, Shourmura S *et al* (1991) in 1.09%. This trunk was seen in 1 specimen in the present study - 2% of specimens, which is closely similar to Adachi's study.

**Table – 7**

**Various Pattern of Coeliac Trunk**

| Sl. No | Name of the authors | Year of Study | No. of specimens | Hepatolieno gastric trunk | Lienogastric trunk | Hepatolieno mesenteric trunk | Coeliaco colic trunk |
|---|---|---|---|---|---|---|---|
| 1. | Lipshutz | 1917 | 83 | 75% | 4% | - | - |
| 2. | Adachi | 1928 | 252 | 87.7% | - | 1.2% | - |
| 3. | Michels | 1955 | 200 | 89% | 2% | 0.5% | 0.5% |
| 4. | Shoumura S *et al* | 2001 | 184 | 90.2% | 1.09% | 1.09% | - |
| 5. | Present study | 2009 | 50 | 92% | 2% | 2% | 2% |

# Chart - 6
# Various Pattern of Coeliac Trunk



***d) Coeliaco-colic Trunk:***

This rare variation had been reported by Michels (1955) in which the origin of middle colic artery from coeliac trunk was found in 1 out of 200 specimens - 0.5%. In my study, it was noticed in 1 out of 50 specimens - 2%, which is closely similar to the above study.

**e) Others:**

Hepatogastric trunk was observed by Lipshutz (1917) in 6%, Michels (1955) in 0.5%. Coeliaco mesenteric trunk was reported by Adachi (1928) in 2.4%, Michels (1955) in 0.4%. In my study, hepatogastric and coeliaco mesenteric trunk was not observed.

**4. Complete and Incomplete Coeliac Trunk:**

Eaton (1917) observed complete coeliac trunk in 86% and incomplete trunk in 12.5% of specimens. Lipshutz (1917) reported complete coeliac trunk in 75% and incomplete in 25%. In the current study, complete coeliac trunk was seen in 96% and incomplete in 4% of specimens.

**5. Tripod of Haller:**

The three branches of coeliac trunk trifurcating from a common point had been observed by Eaton (1917) in 15.5% and by Michels (1955) in 20% of specimens. In my study, the Tripod of Haller was observed in 38% of specimens.

**6**. **Supernumery Branches:**

***a) Inferior Phrenic Artery:***

Pick and Anson (1940) in 47.8% out of 200 cadavers observed the origin of inferior phrenic artery from coeliac trunk. Piao Dx *et al* (1998) stated that the incidence of inferior phrenic artery taking origin from coeliac trunk was 28.2%. In my study, in 32% of the specimens, the inferior phrenic artery took origin from the coeliac trunk as supernumery branch, which is closer to Piao Dx study.

Saeed M *et al* (2003) reported a case in which a common inferior phrenic artery taking origin from coeliac trunk and then dividing into right and left inferior phrenic artery. Such type of common inferior phrenic artery was observed in 1 in 50 specimens (2%) in the my study.

Cicekcibasi AE *et al* (2005) reported a case in which both inferior phrenic arteries took origin from coeliac trunk separately. In my study, the same variation had been recorded in 3 specimens - 6%.

***b) Dorsal Pancreatic Artery:***

Eaton (1917) in 11.2%, Michles (1955) in 5%, Dr. Kalavathy (1980) in 10% of specimens reported dorsal pancreatic artery arising as a branch of coeliac trunk. In my study, the incidence was 12% which is closely similar to Dr.Kalavathy's study.

***c) Superior mesenteric artery:***

Adachi (1928) in 1.2%, Michels (1955) in 0.5% of specimens observed the superior mesenteric artery arising from coeliac trunk. In my study, the same was observed in one specimen - 2%, which is closely similar to Adachi's study.

***d) Middle colic artery:***

Michels (1955) observed the origin of middle colic artery from coeliac trunk in 0.5%. In my study too, it was observed in one specimen (2%).

**7. Length of the Coeliac Trunk:**

In the textbook of Gray's Anatomy, it was stated that the length of the coeliac trunk is 1.5 to 2 cm. In the textbook of Anatomy for Surgeons by Hollinshead, it was stated that its length is 1 to 3 cm. In my study also, the length of the coeliac trunk ranged from 1.1 to 2.3 cm.

**8. Michel's Classification of Coeliac Trunk:**

Michels (1955) classified coeliac trunk into 7 types. According to him, out of 200 speicmens 89%, 3.5%, 0.5%, 5.5%, 0.4%, 1% of specimens belonged to Type I, II, III, IV, V, VI, VII respectively. In my study, out of 50 specimens, 92% belonged to Type I, 2% to Type II, 2% to Type III, 2% to Type V and 2% to Type VII. Type IV and Type VI coeliac trunk were not observed.

## HEPATIC ARTERY

### 1. Origin of Common Hepatic Artery:

Daseler *et al* (1947) reported that the incidence of origin of the common hepatic artery from coeliac trunk was 83.2%. In the present study the incidence was 98%.

Origin of common hepatic artery from aorta was reported by Rossi and Cova (1904) in 3.9%, Daseler *et al* (1947) in 0.2%, Jonathen *et al* (1984) in 0.2%, by Shoumura S *et al* (1991) in 1.08%, Hirari JR *et al* (1994) in 0.2%. In my study, in 2% of specimens the common hepatic artery took origin from aorta which is similar to that of Shoumura S *et al* study (Chart 7).

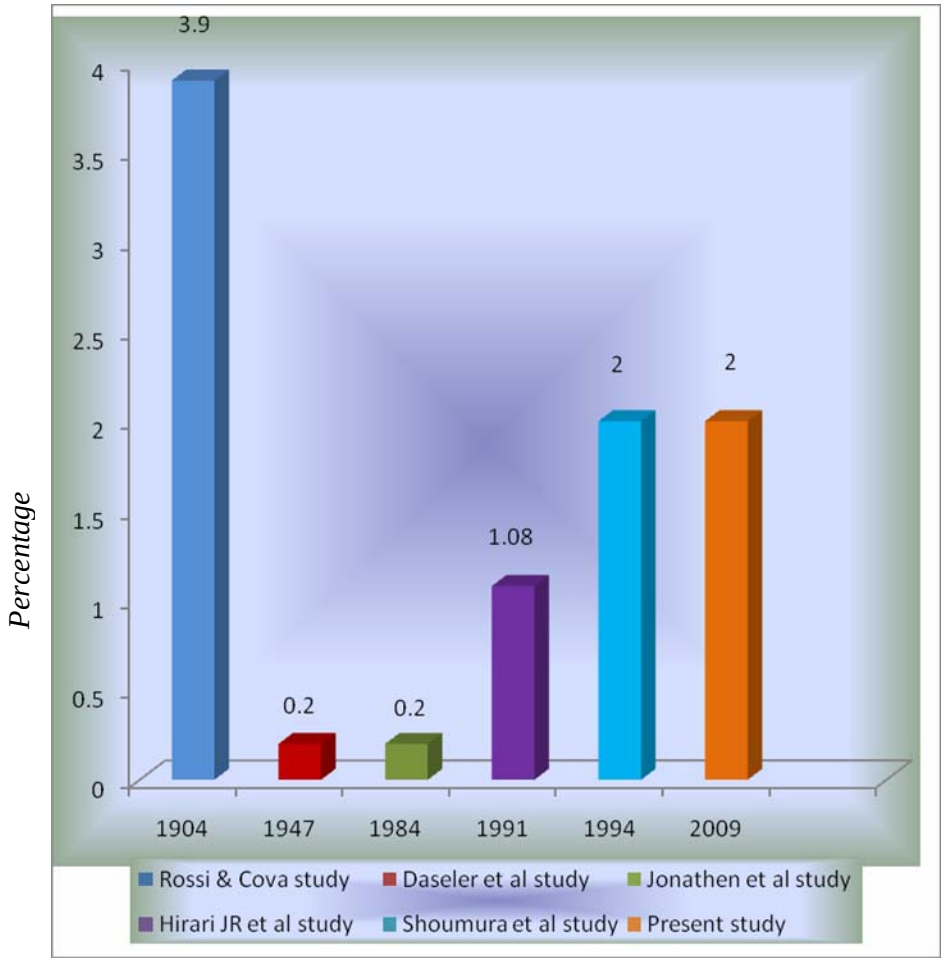
### 2. Trifurcation of Common Hepatic Artery:

Trifurcation of common hepatic artery into right hepatic, left hepatic and gastroduodenal artery was observed by Margaret Kemeny *et al* (1986) in 9% cases, by Bartevello P.L *et al* (2002) in 15%. In this study, the incidence was 8%, which is similar to that of Margaret Kemeny *et al* study.

### 3. Right Hepatic Artery:

E.R.Flint (1922-23) in 79%, Daseler *et al* (1947) in 83.2% and Dorvan A Moosman *et al* (1951) in 85.6%, Arjhansiri K *et al* (2006) in 80.5% of specimens observed the right hepatic artery taking origin from

## Chart – 7
## Replaced Origin of Common Hepatic Artery from Aorta



normal coeliacal hepatic artery. In my study, the incidence was noted in 82% of the specimens which is similar to Daseler *et al* study.

**4. Left Hepatic Artery:**

Daseler *et al* (1947) in 87%, Edward V Johnson *et al* (1952) in 91.4% of the specimens observed the origin of left hepatic artery from normal coeliacal hepatic artery. In my study, the incidence was noted to be 94% of the specimens, which is nearer to that of the Edward V Johnson study.

**3. Aberrant Hepatic Artery:**

Thompson (1933) found aberrant hepatic arteries in 28% of cases. In my study, the incidence was 32%, which is closely similar to the above study.

**4. Aberrant Right Hepatic Artery:**

Daseler *et al* (1947) in 24% out of 500 specimens, Dorvan A Moosman *et al* (1951) in 18.4% out of 250 specimens, Edward V Johnson *et al* (1952) in 20% out of 35 specimens, observed the presence of aberrant right hepatic artery. In the current study, it was noticed in 13 out of 50 specimens - 26% which is closely similar to Daseler *et al* study.

***(a) Replaced Right Hepatic Artery:***

Dorvan A Moosman *et al* (1951) observed replaced right hepatic artery in 36 out of 250 specimens - 14.4%. Margaret M Kemeny *et al* (1986) observed it in 20 out of 100 specimens - 20%. In my study, it was found in 9 out of 50 specimens - 18%, which is similar to Margaret M Kemeny *et al* study.

***(b) Replaced Right Hepatic Artery of Superior Mesenteric Artery:***

Daseler *et al* (1947) in 11.2%, Edward V Johnson *et al* (1952) in 8.6%, Michels (1955) in 11%, Nakayasu *et al* (2000) in 10.2%, Arjhansiri K *et al* (2006) in 11.5% observed the replaced right hepatic artery from superior mesenteric artery. In my study, the incidence was 12%, which is similar to Daseler *et al* and Arjhansiri *et al* study and closer to Michels study (Table 8), (Chart 8).

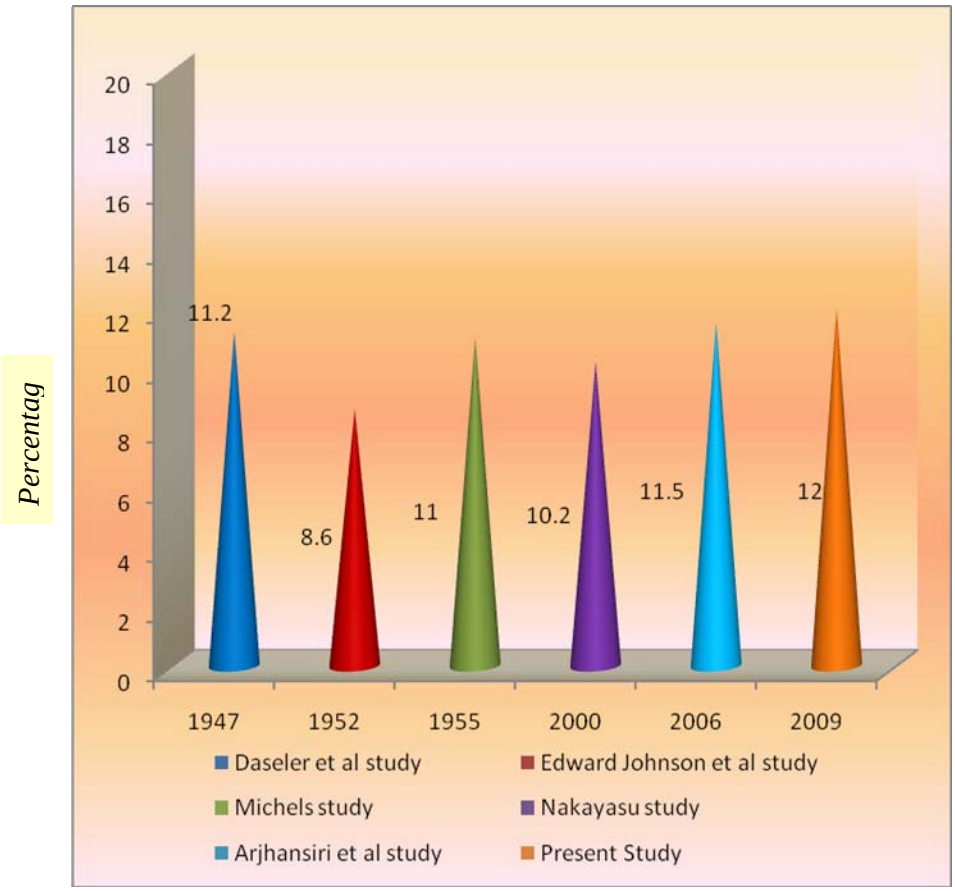
**COURSE:** John M Pierson (1943) and Michles (1955) observed that all the aberrant right hepatic arteries of superior mesenteric artery origin coursed behind the pancreas. Higashi N Hirari (1955), Kahraman G *et al* (1984) reported that aberrant right hepatic artery of superior mesenteric origin had an unusual course of running posterior to the portal vein.

## Table – 8

**Replaced Right Hepatic Artery of Superior Mesenteric Artery Origin**

| Sl. No. | Name of the authors | Year of study | No. of specimens | Percentage |
|---|---|---|---|---|
| 1. | Daseler *et al* | 1947 | 500 | 11.2% |
| 2. | Edward V Johnson | 1952 | 35 | 8.6% |
| 3. | Michels | 1955 | 200 | 11% |
| 4. | Nakayasu | 2000 | 166 | 10.2% |
| 5. | Arjhansiri *et al* | 2006 | 200 | 11.5% |
| 6. | Present study | 2009 | 50 | 12% |

**Chart - 8**
**Replaced Right Hepatic Artery of Superior Mesenteric Artery**



In my study also, all the aberrant right hepatic artery of superior mesenteric origin (12%) coursed posterior to the head of the pancreas and posterior to the portal vein.

***(c) Replaced Right Hepatic Artery from Replaced Common Hepatic Artery of Aorta:***

Daseler *et al* (1947) reported this type of variation in 1 out of 500 specimens - 0.2%. In my study, it was noticed in 1 out of 50 specimens (2%).

***(d) Accessory Right Hepatic Artery:***

Daseler *et al* (1947) in 7.2%, Dorvan A Moosman *et al* (1951) in 4% of specimens observed the presence of accessory right hepatic artery. In my study, it was observed in 8% which is similar to Daseler *et al* study.

***(e) Accessory Right Hepatic Artery from Gastroduodenal Artery:***

Daseler *et al* (1947) noticed this artery in 5 out of 500 specimens - 1%. Futura Ali *et al* (2001) noticed it in 2% of the specimens. In my study, it was noticed in 3 out of 50 specimens - 6%, which is nearer to that of Futura Ali *et al* study.

**5. Replaced Left Hepatic Artery from Left Gastric Artery:**

Margaret M Kemeny *et al* (1986) observed the presence of replaced left hepatic artery from left gastric artery in 4 out of 100 specimens - 4%. Arjhansiri K *et al* (2006) observed it in 5.5% of cases. In the present study, it was observed in 2 out of 50 specimens - 4%, which coincides with the result of the Margaret M Kemeny *et al* study.

**6. Middle Hepatic Artery:**

Adachi (1928) reported the origin of middle hepatic artery from right hepatic, left hepatic and proper hepatic artery in 50%, 40% and 10% respectively.

Michles (1955) observed its origin from right hepatic, left hepatic and proper hepatic artery in 45%, 45% and 10% respectively.

In my study, the origin of middle hepatic artery was noticed in 31 specimens (62%). Out of which, its origin from right hepatic, left hepatic and proper hepatic artery was seen in 32%, 22%, and 8% of the specimens respectively and in rest of the 38% of the specimens, middle hepatic artery was not noticed.

***7.Classification of Hepatic Artery:***

Jonathen (1994) classified hepatic artery into 5 types. According to him, out of 1000 specimens studied, 75%, 9.7%,10.6%, 4.5% and 0.2% of specimens belonged to Type I, II, III, IV and V. In my study,

out of 50 specimens, 70% belonged to Type I, 4% to Type II, 12% to Type III, 2% to Type V and Type IV specimens were not noticed in any of the specimens. Rest of the 12% of specimens could not be classified under Jonathen study, out of which right and left hepatic artery arose from common hepatic artery in 8% and right hepatic artery took replaced origin from gastroduodenal artery in 4% of specimens.

**8. Other Branches of Hepatic Artery:**

***(a) Gastroduodenal Artery:***

Daseler *et al* (1947) observed that this artery took origin from common hepatic artery in 75.4%, from replaced common hepatic artery in 3.6%, from right hepatic artery in 7%, from coeliac trunk in 2.5%, from aorta in 0.2% and absent in 2.8%. Edward V Johnson *et al* (1952) reported its origin from common hepatic artery in all the cases.

In my study, it took origin from the common hepatic artery in all the specimens; among which in one of the specimens, it took origin from the replaced common hepatic artery of aorta.

***(b) Right Gastric Artery:***

The origin of right gastric artery from proper hepatic artery, left hepatic artery, gastroduodenal artery, right hepatic artery was observed by Daseler *et al* (1947) in 50%, 32.4%, 13.2%, 4%, by Michels (1955) in 40%, 40.5%, 8%, and 5.5% respectively. In my study, its origin from

proper hepatic artery, left hepatic artery, gastroduodenal artery and right hepatic artery was observed to be 50%, 30%, 12%, and 6% respectively. The findings of the present study are similar to that of Daseler *et al* study (Table 9).

Eckmann I Krahn (1984) observed its origin from common hepatic artery in 4% of specimens. In my study, in 1 specimen - 2%, it took origin from the common hepatic artery, which is closely similar to the above study.

***(c) Cystic Artery:***

Daseler *et al* (1947) observed the origin of cystic artery from right hepatic artery in 84.4%, aberrant right hepatic artery in 12.7% and from other sources in 3%. Dorvann A Moosman *et al* (1951) observed the origin of cystic artery from right hepatic artery in 86%, aberrant right hepatic artery in 10% and from other sources in 4%. Michels (1955) observed the origin of cystic artery from right hepatic artery in 78%, aberrant right hepatic artery in 18% and from other sources in 5%.

In my study, its origin was found to be from right hepatic artery in 78%, from aberrant right hepatic artery in 20% and other source like gastroduodenal artery in 2%. The findings are closely similar to that of Michels study (Table 10).

**Table – 9**
**Origin of Right Gastric Artery**

| Sl. No | Name of the authors | Year of study | *Origin of Right gastric artery* | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | **Proper hepatic artery** | **Left hepatic artery** | **Gastro duodenal artery** | **Right hepatic artery** | **Coeliac trunk** | **Common hepatic artery** |
| 1. | Daseler | 1947 | 50% | 32.4% | 13.2% | 4% | 0.4% | - |
| 2. | Michels | 1955 | 40% | 40.5% | 8% | 5.5% | - | - |
| 3. | Eckmann I | 1984 | 53% | 15% | 8% | - | - | 4% |
| 4. | Present study | 2009 | 50% | 30% | 12% | 6% | - | 2% |

**Table – 10**
**Origin of Cystic Artery**

| Sl. No | Year of study | Name of the authors | No. of specimens | Right hepatic artery | RHA of Others sources | Others sources |
|---|---|---|---|---|---|---|
| 1. | 1947 | Daseler et al | 500 | 84.4% | 12.7% | 3% |
| 2. | 1951 | Dorvan A<br>Mossman | 250 | 86% | 10% | 4% |
| 3. | 1955 | Michels | 200 | 78% | 17% | 5% |
| 4. | 2009 | Present study | 50 | 78% | 20% | 2% |

## SPLENIC ARTERY

### 1. Origin:

Jauregui E (1998) found in his studies that the origin of splenic artery was from coeliac trunk only. In my study also, in all the specimens, splenic artery took origin from coeliac trunk only.

### 2. Length:

Michels (1955) found the varying length of splenic artery from 8 to 12 cm. Jaurequi E (1998) found to be 10.6 cm. In my study, the length varied from 8 cm to 13.5 cm which correlates with that of the previous studies.

### 3. Tortuosity Index:

Arantius (1571) was the first to notice its tortuosity. Sylvester PA (1955) in 73 specimens measured the tortuosity index. According to him, it is the ratio between the curved length and the straight length of splenic artery. The ratio was measured and ranged from 1.02 to 1.29.

### 4. Relation to the Pancreas:

Franz K (1896) in his short series of 28 cases, found the splenic artery running along the upper border of pancreas in 12 (42.8%), behind it in 10 (35.7%), somewhat above it in 4 (14.3%) and front of it in 2 (7%) cases. Pandey SK *et al* (2004) found its suprapancreatic course in

74.1% cases, enteropancreatic course in 18.5% intrapancreatic in 4.6%, retropancreatic in 2.8%.

In my study, in 38 specimens (76%), splenic artery had suprapancreatic course, 10 specimens (20%) had retropancreatic course, 2 specimens (4%) had intrapancreatic course. No specimens had enteropancreatic course.

**5. Branches:**

***(a) Polar Arteries:***

Liu D *et al* (1996) reported the incidence of superior polar artery and inferior polar artery in 31.3% and 38.8% respectively. Seok kil Zeon *et al* (1998) found its incidence in 76% and 24% respectively. Jauregui E (1999) found its incidence in 53% and 33% respectively. In my study, superior and inferior polar artery was observed in 30% and 36% of specimens respectively. These findings are similar to that of Liu D *et al* study.

The presence of both polar arteries was reported by Liu D *et al* (1996) in 13.3% In the present study, the incidence of both polar arteries is 8%, which is closely similar to the above study (Table 11), (Chart 9).

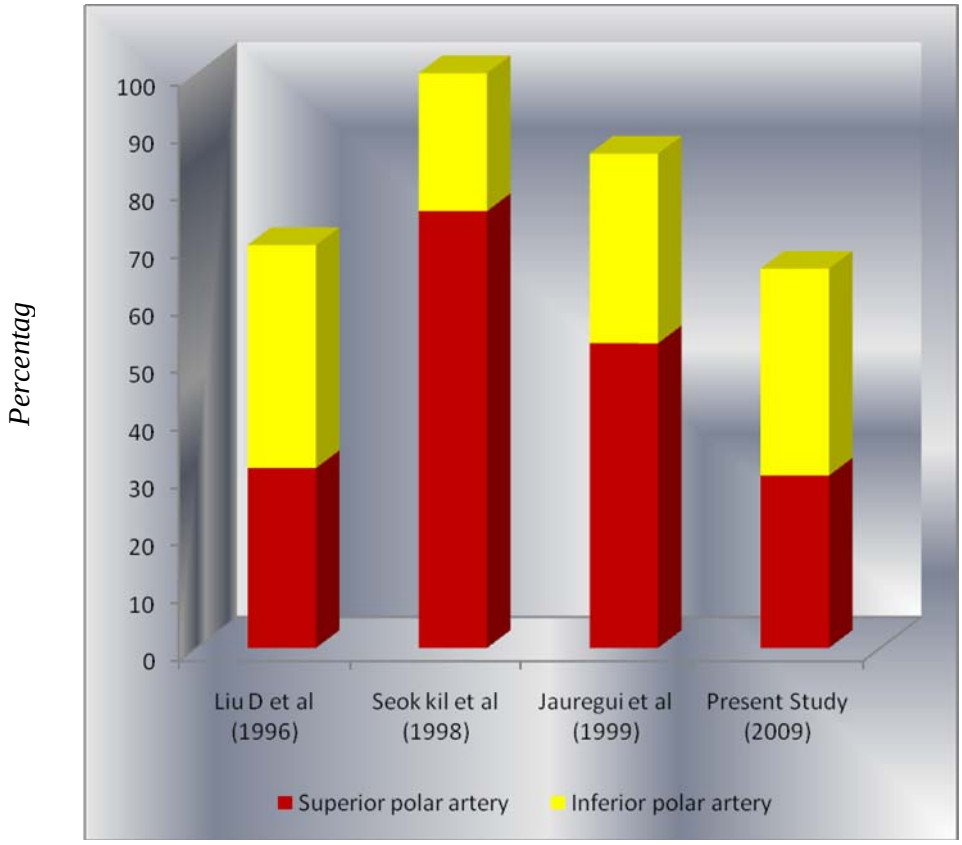
**Table – 11**

## Polar Arteries from Splenic Artery

| Sl. No. | Name of the authors | Year of study | No. of Specimens | Superior polar artery | Inferior polar artery | Both polar arteries |
|---|---|---|---|---|---|---|
| 1. | Liu D et al | 1996 | 280 | 31.3% | 38.8% | 13.3% |
| 2. | Seok Kil Zeon | 1998 | 50 | 76% | 24% | - |
| 3. | Jauregui E | 1999 | - | 53% | 33% | - |
| 4. | Present Study | 2009 | 50 | 30% | 36% | 8% |

# Chart- 9

## Polar Arteries from Splenic Artery



***(b) Posterior gastric artery:***

Posterior gastric from splenic artery was reported by Trubel W *et al* (1988) in 27%. In my study, the incidence was 28% which correlates with the above study.

***(c) Gastrosplenic artery:***

Trubel W *et al* (1988) described about the gastrosplenic artery which divides into polar branch to supply the spleen and a gastric branch to supply the stomach. In this study, this gastrosplenic artery was noted in 12% of specimens.

***(d) Accessory splenic artery:***

Michels (1955) found an accessory splenic artery which was actually a superior polar artery running parallel to the splenic artery. In my study, an inferior polar artery ran as an accessory splenic artery, which was very parallel to the splenic artery in 1 of the specimens (2%).

**LEFT GASTRIC ARTERY**

**1. Origin:**

Sawai K *et al* (1984) observed the origin of left gastric artery from the coeliac trunk in 94.4%, splenic artery in 2.7%, aorta in 2.1% and common hepatic artery in 0.3%. In my study, left gastric artery took origin from coeliac trunk in 96%, from splenic artery in 2%, from aorta

as a direct branch in 2% and none from common hepatic artery. The present study correlates with the previous study (Chart 10).

The origin of left gastric artery from aorta was reported by Eaton (1917) in 4.5%, by Lipshutz (1917) in 1.5%, Yildirim M et al (1998) in 0.5 to 1.5%. In my study, its incidence was 2%, which is similar to Lipshutz study.

**2**. **Division and Distribution:**

Reeves (1920) described the left gastric artery dividing into an anterior and posterior branch to supply the stomach. Lipshutz (1917) also found it so divided and gave off branches to both the anterior and posterior surfaces of the stomach. In my study also the above finding was noted in one of the specimens (2%).

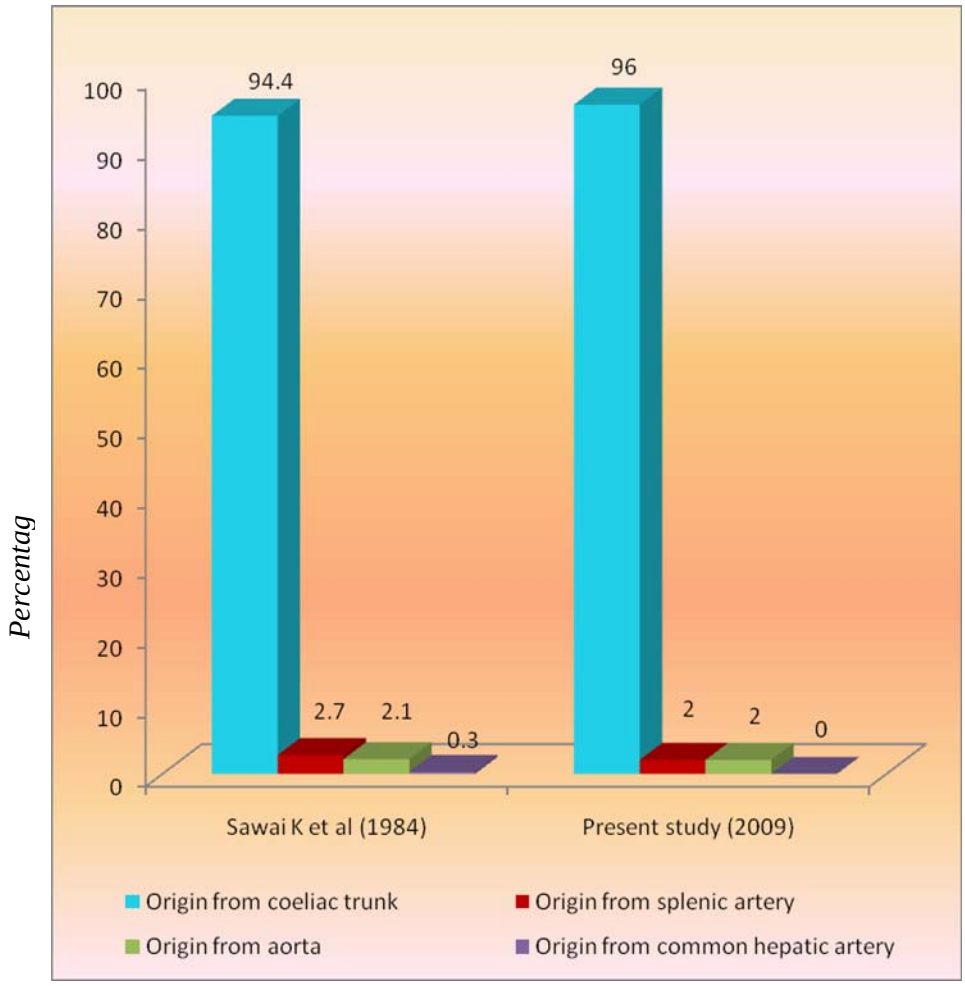
**3) Supernumery Branches:**

***(a) Left Inferior Phrenic Artery:***

Piao Dx *et al* (1998) reported 2.9% of cases inferior phrenic artery took origin from left gastric artery. In my study, inferior phrenic artery took origin from the left gastric artery in 4% of specimens, which is nearer to the previous study.

Hirari Y *et al* (2000) reported gastrophrenic trunk with hepatolienomesenteric trunk. The gastrophrenic trunk divided branched into left gastric artery with both right and left inferior phrenic arteries. In

# Chart – 10
# Origin of Left Gastric Artery



my study also, the similar findings were observed in one of the specimens (2%).

***(b) Replaced left hepatic artery:***

Margaret M Kemeny (1986) reported the presence of replaced left hepatic artery from left gastric artery in 4% of the specimens. In the present study, replaced left hepatic artery of left gastric artery was found in 4% of the specimens, which is similar to the previous study.

# *CONCLUSION*

# CONCLUSION

The coeliac trunk took origin from the ventral surface of the aorta in all the 50 specimens. The various pattern of the trunk were normal hepatolienogastric trunk in 92%, lienogastric trunk in 2%, hepatolieno mesenteric trunk in 2%, coeliaco-colic trunk in 2%. In one specimen, coeliac trunk divided into common hepatic & splenic arteries, the left gastric artery took origin from the splenic artery. 96% of specimens had complete coeliac trunk and 4% had incomplete coeliac trunk. Tripod of Haller was seen in 38% of the specimens. The length ranged from 1.1 to 2.3 cm. The supernumery branches observed from the coeliac trunk were inferior phrenic artery in 32%, dorsal pancreatic artery in 12%, superior mesenteric artery in 2% and middle colic artery in 2%.

Regarding Hepatic artery, the common hepatic artery took origin from coeliac trunk in 98% and directly from aorta in 2%. In 8% of the specimens, the common hepatic artery trifurcated into right hepatic, left hepatic and gastroduodenal arteries. In 16% of the specimens, it continued only as left hepatic artery and in 4% it continued only as right hepatic artery.

The right hepatic artery took origin from proper hepatic artery in 74%, from common hepatic artery in 8%, replaced origin from superior mesenteric artery in 10%, from gastroduodenal artery in 4%, from

replaced common hepatic artery in 2%. In one specimen, there were two replaced right hepatic arteries, one arising from superior mesenteric artery and another from gastroduodenal artery. 26% of the specimens had aberrant right hepatic artery, of which 18% were replaced and 8% were accessory. Origin of accessory right hepatic artery was from gastroduodenal artery in 4% and from proper hepatic artery in 2%.

The left hepatic artery took origin from proper hepatic artery in 86%, from common hepatic artery in 8%, replaced origin from left gastric artery in 4% and from replaced common hepatic artery in 2%. The middle hepatic artery was noticed in 62% of the specimens.

In all the specimens, the gastroduodenal artery took origin from the common hepatic artery. The right gastric artery took origin from proper hepatic, left hepatic, gastroduodenal, right hepatic and common hepatic arteries in 50%, 30%, 12%, 6% and 2% respectively. The cystic artery took origin from right hepatic artery in 78%, from aberrant right hepatic artery in 20% and from gastroduodenal artery in 2% of the specimens.

Regarding the Splenic artery, it took origin from the coeliac trunk in all the specimens. Its length ranged from 8 to 13.5 cm. Its tortousity index was from 1.02 to 1.29. Suprapancreatic course in 76%, retropancreatic course in 20% and intrapancreatic course in

4% were noted. Apart from the usual branches, the superior polar (30%), inferior polar (36%) and both polar arteries (8%) were found. 18% of specimens had dorsal pancreatic artery, 28% had posterior gastric artery and 12% had gastrosplenic artery.

Regarding the Left gastric artery, it took origin from the coeliac trunk in 96%, from the aorta in 2% and from the splenic artery in 2% of the specimens.

The radiological study done in one patient was found to be normal.

The knowledge of the various branching pattern, variations in the origin and the presence of supernumery branches and aberrant arteries which had been enumerated in this study will be helpful to the surgeons and the radiologists.

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# *ANNEXURE*

# List of Abbreviations used in this Study

| | | |
|---|---|---|
| CT | - | Coeliac trunk |
| HLG | - | Hepatolienogastric trunk |
| HLM | - | Hepatolienomesentric trunk |
| LG | - | Lienogastric trunk |
| CC | - | Coeliaco-colic trunk |
| CHA | - | Common hepatic artery |
| PHA | - | Proper hepatic artery |
| RHA | - | Right hepatic artery |
| LHA | - | Left hepatic artery |
| MHA | - | Middle hepatic artery |
| RGA | - | Right gastric artery |
| LGA | - | Left gastric artery |
| GDA | - | Gastroduodenal artery |
| Cys A | - | Cystic artery |
| Spl A | - | Splenic artery |
| DPA | - | Dorsal pancreatic artery |
| LIPA | - | Left inferior pancreatic artery |
| RIPA | - | Right inferior phrenic artery |
| CIPA | - | Common inferior phrenic artery |
| PGA | - | Posterior gastric artery |
| GSA | - | Gastrosplenic artery |
| Supra | - | Supra pancreatic course |
| Retro | - | Retro pancreatic course |
| Intra | - | Intra pancreatic course |
| Sup | - | Superior polar artery |
| Inf | - | Inferior polar artery |
| CBD | - | Common bile duct |
| PV | - | Portal vein |
| Ao | - | Aorta |
| SMA | - | Superior mesenteric artery |
| Acc | - | Accessory |
| Rep | - | Replaced |

# MASTER CHART

| Token No | COELIAC TRUNK | | | | COMMON HEPATIC ARTERY | | | | | | | | | | | | LEFT GASTRIC ARTERY | | SPLENIC ARTERY | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Pattern | Superumery branches | Tripod of Haller | Length (Cm) | Origin | PHA +/- | RHA origin | Origin of Aberrant RHA | | LHA Origin | Origin of Aberrant LHA | | MHA Origin | GDA Origin | RGA Origin | Cystic artery origin | Origin | Super numery branches | Curved length (cm) | Straight length (cm) | Tootusity Index | Relation to pancreas | Polar arteries | PGA /GSA/DPA/LGA |
| | | | | | | | | Rep RHA | Acc RHA | | Rep LHA | Acc LHA | | | | | | | | | | | | |
| 1 | HLG | - | - | 1.2 | CT | + | PHA | - | - | PHA | - | - | RHA | CHA | PHA | RHA | CT | - | 10.0 | 9.4 | 1.06 | Retro | Inf | PGA |
| 2 | HLG | DPA | - | 1.1 | CT | + | PHA | - | - | PHA | - | - | - | CHA | PHA | RHA | CT | - | 10.2 | 9.7 | 1.05 | Supra | Inf | - |
| 3 | CT with CHA & Spl. A. | - | - | 1.1 | CT | + | PHA | - | - | PHA | - | - | LHA | CHA | PHA | RHA | Spl. A | - | 8.5 | 7.9 | 1.07 | Supra | - | LGA |
| 4 | HLG | LIPA RIPA | + | 1.3 | CT | + | PHA | - | - | PHA | - | - | - | CHA | PHA | RHA | CT | - | 9.5 | 8.3 | 1.15 | Retro | Sup | PGA |
| 5. | HLG | - | - | 2.0 | CT | - | CHA | - | - | CHA | - | - | RHA | CHA | LHA | RHA | CT | - | 9.2 | 8.0 | 1.15 | Supra | - | DPA |
| 6 | HLG | - | - | 1.8 | CT | + | PHA | - | - | PHA | - | - | RHA | CHA | GDA | RHA | CT | - | 11.5 | 10.1 | 1.14 | Supra | Inf | - |
| 7 | HLG | - | - | 1.2 | CT | + | PHA | - | - | PHA | - | - | RHA | CHA | PHA | RHA | CT | - | 8.2 | 7.4 | 1.11 | Supra | - | - |
| 8 | HLG | LIPA | + | 2.0 | CT | - | - | GDA & SMA | - | PHA | - | - | RHA | CHA | GDA | Rep RHA of GDA & SMA | CT | - | 10.2 | 8.4 | 1.21 | Supra | Inf | PGA |
| 9 | HLG | - | - | 1.9 | CT | + | PHA | - | - | PHA | - | - | LHA | CHA | GDA | RHA | CT | - | 9.5 | 7.7 | 1.23 | Supra | Sup | PGA |
| 10 | HLG | CIPA | - | 1.2 | CT | + | PHA | - | - | PHA | - | - | - | CHA | PHA | RHA | CT | - | 11.5 | 9.0 | 1.28 | Supra | Sup & Inf | PGA |
| 11 | HLG | LIPA | - | 1.8 | CT | - | PHA | - | - | - | LGA | - | - | CHA | RHA | RHA | CT | Rep LHA | 11.5 | 11.2 | 1.03 | Supra | Inf | - |
| 12 | HLG | - | + | 1.7 | CT | + | PHA | - | - | PHA | - | - | RHA | CHA | PHA | RHA | CT | - | 9.4 | 8.6 | 1.09 | Supra | Inf | DPA |
| 13 | HLG | - | - | 1.2 | CT | + | PHA | - | - | PHA | - | - | RHA | CHA | PHA | RHA | CT | - | 10.3 | 9.7 | 1.06 | Supra | Inf | - |
| 14 | HLG | LIPA | + | 2.0 | CT | + | PHA | - | - | PHA | - | - | PHA | CHA | PHA | RHA | CT | - | 10.0 | 9.2 | 1.09 | Supra | Sup | - |
| 15 | HLG | - | - | 2.3 | CT | + | PHA | - | - | PHA | - | - | LHA | CHA | PHA | RHA | CT | - | 11.0 | 9.8 | 1.12 | Retro | Sup & inf | GSA |
| 16 | HLG | LIPA | + | 1.1 | CT | + | PHA | - | - | PHA | - | - | - | CHA | GDA | RHA | CT | - | 8.5 | 7.4 | 1.15 | Supra | Sup | PGA |
| 17 | HLG | LIPA | - | 2.0 | CT | - | CHA | - | - | CHA | - | - | - | CHA | RHA | RHA | CT | - | 8.3 | 7.0 | 1.19 | Supra | Sup | PGA |
| 18 | HLG | RIPA LIPA | + | 1.7 | CT | + | PHA | - | GDA | PHA | - | - | RHA | CHA | LHA | Acc RHA of GDA | CT | - | 12.0 | 10.5 | 1.14 | Supra | - | GSA |
| 19 | HLG | - | + | 1.3 | CT | - | - | SMA | - | PHA | - | - | LHA | CHA | LHA | Rep RHA of SMA | CT | - | 8.4 | 8.0 | 1.05 | Retro | - | PGA |
| 20 | HLG | DPA | - | 1.6 | CT | - | - | GDA | - | PHA | - | - | RHA | CHA | LHA | Rep RHA of GDA | CT | - | 11.3 | 10.8 | 1.05 | Supra | Inf | - |
| 21 | HLM | SMA DPA | - | 2.3 | CT | + | PHA | - | - | PHA | - | - | RHA | CHA | PHA | RHA | Ao | LIPA RIPA | 11.0 | 9.7 | 1.13 | Supra | Sup & Inf | - |
| 22 | HLG | RIPA | - | 2.0 | CT | - | - | SMA | | PHA | - | - | - | CHA | CHA | Rep RHA of SMA | CT | - | 12.0 | 10.2 | 1.22 | Supra | Sup | GSA |
| 23 | HLG | - | - | 1.6 | CT | - | CHA | - | - | CHA | - | - | - | CHA | LHA | RHA | CT | - | 8.3 | 7.0 | 1.19 | Intra | Inf | - |

| Token No. | COELIAC TRUNK | | | | COMMON HEPATIC ARTERY | | | | | | | | | | | | | LEFT GASTRIC ARTERY | | SPLENIC ARTERY | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 24 | HLG | - | - | | 2.3 | CT | + | PHA | - | - | PHA | - | - | - | CHA | PHA | RHA | CT | - | 12.3 | 11.0 | 1.12 | Supra | Sup | DPA |
| 25 | HLG | LIPA | - | | 1.2 | CT | + | PHA | - | - | PHA | - | - | RHA | CHA | LHA | RHA | CT | - | 8.3 | 7.1 | 1.17 | Intra | - | - |
| | Pattern | Superumery broanches | Tripod of Haller | Length (cm) | Origin | PHA +/- | RHA origin | Origin Aberrant RHA | | LHA Origin | Origin Aberrant LHA | | MHA Origin | GDA Origin | RGA Origin | Cystic artery origin | Origin | Supernumery branches | Curved length (cm) | Stright length (cm) | Tootusity Index | Relation to pancreas | Polar arteries | PGA /GSA/DPA/LGA |
| | | | | | | | | Rep RHA | Acc RHA | | Rep LHA | Acc LHA | | | | | | | | | | | | |
| 26 | HLG | DPA | + | 1.3 | CT | + | PHA | - | - | PHA | - | - | PHA | CHA | PHA | RHA | CT | - | 8.6 | 8.0 | 1.08 | Supra | Inf | DPA |
| 27 | HLG | DPA | - | 2.0 | CT | + | PHA | - | - | PHA | - | - | - | CHA | LHA | RHA | CT | - | 9.5 | 8.2 | 1.16 | Retro | Sup | PGA |
| 28 | HLG | LIPA | + | 1.8 | CT | + | PHA | - | PHA | PHA | - | | RHA | CHA | PHA | Acc RHA of PHA | CT | - | 10.0 | 9.4 | 1.06 | Supra | Inf | PGA GSA |
| 29 | CC | Mid. col .A. | + | 1.2 | CT | + | PHA | - | - | PHA | - | - | - | CHA | GDA | RHA | CT | - | 12.4 | 10.3 | 1.20 | Supra | Inf | GSA |
| 30 | HLG | - | + | 1.4 | CT | + | PHA | - | GDA | PHA | - | - | PHA | CHA | LHA | RHA | CT | - | 8.4 | 7.0 | 1.20 | Supra | Sup | - |
| 31 | HLG | - | - | 2.0 | CT | - | - | GDA | - | PHA | - | - | - | CHA | LHA | Rep RHA of GDA | CT | - | 12.4 | 10.0 | 1.25 | Supra | Sup | - |
| 32 | HLG | - | - | 1.4 | CT | + | PHA | - | - | PHA | - | - | LHA | CHA | PHA | RHA | CT | - | 13.5 | 13.3 | 1.02 | Retro | - | DPA |
| 33 | HLG | RIPA LIPA | - | 1.6 | CT | - | CHA | - | - | CHA | - | - | - | CHA | GDA | RHA | CT | - | 8.2 | 8.0 | 1.02 | Supra | Inf | - |
| 34 | HLG | - | - | 1.8 | CT | - | - | SMA | - | PHA | - | - | LHA | CHA | LHA | Rep RHA of SMA | CT | - | 11.3 | 9.2 | 1.23 | Supra | Sup &Inf | PGA |
| 35 | HLG | - | - | 1.3 | CT | + | PHA | - | - | PHA | - | - | RHA | CHA | LHA | RHA | CT | - | 12.0 | 11.2 | 1.07 | Supra | Inf | - |
| 36 | HLG | LIPA | + | 1.5 | CT | + | PHA | - | - | PHA | - | - | LHA | CHA | PHA | RHA | CT | - | 11.4 | 10.6 | 1.08 | Supra | - | - |
| 37 | HLG | - | + | 1.8 | CT | - | PHA | - | - | - | LGA | - | - | CHA | RHA | RHA | CT | Rep LHA | 11.2 | 9.8 | 1.14 | Supra | Inf | DPA |
| 38 | HLG | RIPA | + | 1.0 | CT | + | PHA | - | - | PHA | - | - | - | CHA | PHA | RHA | CT | - | 8.2 | 7.7 | 1.07 | Supra | Sup | PGA |
| 39 | HLG | - | - | 1.4 | CT | + | PHA | - | - | PHA | - | - | RHA | CHA | PHA | RHA | CT | - | 9.0 | 8.6 | 1.05 | Supra | - | DPA |
| 40 | HLG | - | + | 1.8 | CT | + | PHA | - | - | PHA | - | - | LHA | CHA | PHA | RHA | CT | - | 11.4 | 10.1 | 1.13 | Supra | Sup | - |
| 41 | HLG | - | - | 2.0 | CT | + | PHA | - | - | PHA | - | - | RHA | CHA | PHA | RHA | CT | - | 13.0 | 10.5 | 1.23 | Supra | Inf | GSA |
| 42 | HLG | - | + | 1.8 | CT | + | PHA | - | GDA | PHA | - | - | LHA | CHA | LHA | GDA | CT | - | 10.6 | 9.1 | 1.17 | Supra | Inf | PGA |
| 43 | HLG | - | - | 1.3 | CT | + | PHA | - | - | PHA | - | - | - | CHA | PHA | RHA | CT | - | 12.2 | 10.0 | 1.22 | Retro | - | DPA |
| 44 | HLG | LIPA | + | 1.4 | CT | + | PHA | - | - | PHA | - | - | - | CHA | LHA | RHA | CT | - | 9.7 | 9.3 | 1.04 | Retro | Sup | - |
| 45 | LG | LIPA | - | 1.4 | Ao | + | - | PHA of Rep CHA | - | - | PHA of Rep CHA | - | RHA | Rep CHA | PHA | RHA | CT | - | 11.7 | 10.4 | 1.13 | Supra | - | - |
| 46 | HLG | - | - | 2.3 | CT | + | PHA | - | - | PHA | - | - | LHA | CHA | PHA | RHA | CT | LIPA | 9.8 | 7.6 | 1.29 | Supra | Sup | - |
| 47 | HLG | DPA | + | 1.3 | CT | + | PHA | - | - | PHA | - | - | PHA | CHA | PHA | RHA | CT | - | 8.3 | 7.0 | 1.19 | Retro | - | PGA |
| 48 | HLG | - | + | 2.0 | CT | - | - | SMA | - | PHA | - | - | LHA | CHA | LHA | Rep RHA of SMA | CT | - | 9.8 | 9.0 | 1.09 | Supra | Sup | DPA |
| 49 | HLG | - | - | 1.4 | CT | + | PHA | - | - | PHA | - | - | - | CHA | PHA | RHA | CT | - | 8.0 | 7.3 | 1.10 | Retro | Inf | - |
| 50 | HLG | - | - | 1.1 | CT | - | - | SMA | - | PHA | - | - | - | CHA | LHA | Rep RHA of SMA | CT | - | 9.3 | 9.1 | 1.02 | Supra | - | - |

CT - Coeliac trunk
LG- Lienogastric trunk
HLG - Hepatolienogastric trunk
HLM - Hepatolienomesenteric trunk
CC-Coeliaco-colic trunk
Mid.col.A.- Middle colic artery
Rep - Replaced
Acc - Accessory
Spl.A- Splenic artery
Supra - Supra pancreatic
Retro - Retro pancreatic
Intra - Intra pancreatic